PB-216 458

TO DEMONSTRATE THE EFFECTIVENESS OF IODINE FOR THE DISINFECTION OF PUBLIC WATER SUPPLIES AND TO DETERMINE THE PHYSIOLOGICAL EFFECTS ON A HUMAN POPULATION

Florida University
Gainesville, Florida

10 March 1967

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PB 216 458

Fifth Progress Report

of

A Demonstration Project Grant

from

The Division of Research and Training Grants
Federal Water Pollution Control Administration

*WPD 19-04-66

"To Demonstrate the Effectiveness of Iodine for the Disinfection of Public Water Supplies and to Determine the Physiological Effects on a Human Population"

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and
Research Professor Emeritus of Chemistry and
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Gainesville, Florida

Period covered: July 1, 1966 through February 28, 1967

March 10, 1967

*Transferred from the University of Florida to the City of Gainesville, Florida, effective July 1, 1966.

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2. Summary Statement

The water supply of the three institutions at Lowell has been continuously disinfected with iodine since October, 1963. The general health and thyroid function of the 29 remaining inmates of the original test group were re-evaluated in December, 1966. All continue to be in good health and have no evidence of impaired thyroid function. Thus, there is no evidence in these subjects that long-term use of an iodinated water supply has been deleterious to health. Additional inmates are being examined and added to the test group.

Iodine was added to the water supply of the City of Gainesville for a twelve-hour period on February 23, 1967. A dosage of 1 ppm was added to the water which contained about 2 ppm of combined chlorine. Iodine residuals were maintained to the ends of the system by reoxidation of the iodide ion. Iodate formation was not significant. This preliminary test was terminated after twelve hours because of the formation of tastes and odors not predicted by laboratory and field work, and their source is now being investigated. Work on the use of iodine for the disinfection of swimming pool water continues to receive wide attention and work in this area will be carried out with the Georgia State Department of Health during the summer of 1967. Papers presented or to be presented number 11; papers published or submitted for publication 9; degrees awarded or to be awarded to members of project staff 7.

Details of Illustrations in this document may be better studied on microfiche.

3 (a) Concise Statement of Progress

A. Studies at the Lowell Institutions

1. Chronological Record of Iodine Feed

Disinfection of water with elemental iodine has been continued at both the women's prison, the Forest Hill School for Girls, and the male unit. Except for power failures and downtime due to pump maintenance (about four days since June 1965) iodine has been continuously added to the water systems of the three institutions since October 28, 1963, or approximately 3 1/3 years. The dosage added was 1 ppm for the first 9 months; 5 ppm of elemental iodine plus iodide for 2 months; gradually reduced dosages from 1 ppm to 0.3 ppm over a period of 10 months; and a dosage of 1 ppm for the remaining 20 months. (Figure 1).

By means of a halogen residual recorder at the pumping station and another at the end of the distribution system, the iodine demand of the system has been determined, as illustrated in Figure 2. Studies to determine the effect of pH on system demand are in progress and will be presented elsewhere in this report.

2. Bacteriology

Bacteriological analyses are made each week on the water from the two systems. A total of 10 samples from selected points in the distribution systems are analyzed each week at Phelps Laboratory, and another 10 samples are collected and tested by the Florida State Board of Health. A comparison of the results from these two laboratories for a typical two-month period in 1966 is shown in Figure 3. Stations 1-3 are raw water (wells), Station 4 is at a point where the contact time of iodine is approximately 4 seconds, and Stations 5-10 are treated (disinfected) water. The effectiveness of iodine is dramatically illustrated by comparing the obviously contaminated raw water with the treated water from Stations 5-10.

In summary, of a total of more than two thousand samples of iodinated water collected from the two systems and examined by the Phelps Laboratory and the Florida State Board of Health, less than 1% have shown the presence of coliform organisms, and it is believed that most of these resulted from improper sampling.

3. Physiologic Response to Iodine

During the long-term study on the engineering and bacteriological aspects of iodinating a community water supply, there have been repeated assessments of the effect of iodinated water on the general health and thyroid function of the personnel using this water. A report of these assessments after nine months of exposure to iodinated water was published in June, 1966 (J. Clin. Endocrinol. and Met. 26, 619-625, 1966). Twenty-nine individuals who have been using this water for three years were recently re-evaluated. All continue to be in good health and have no

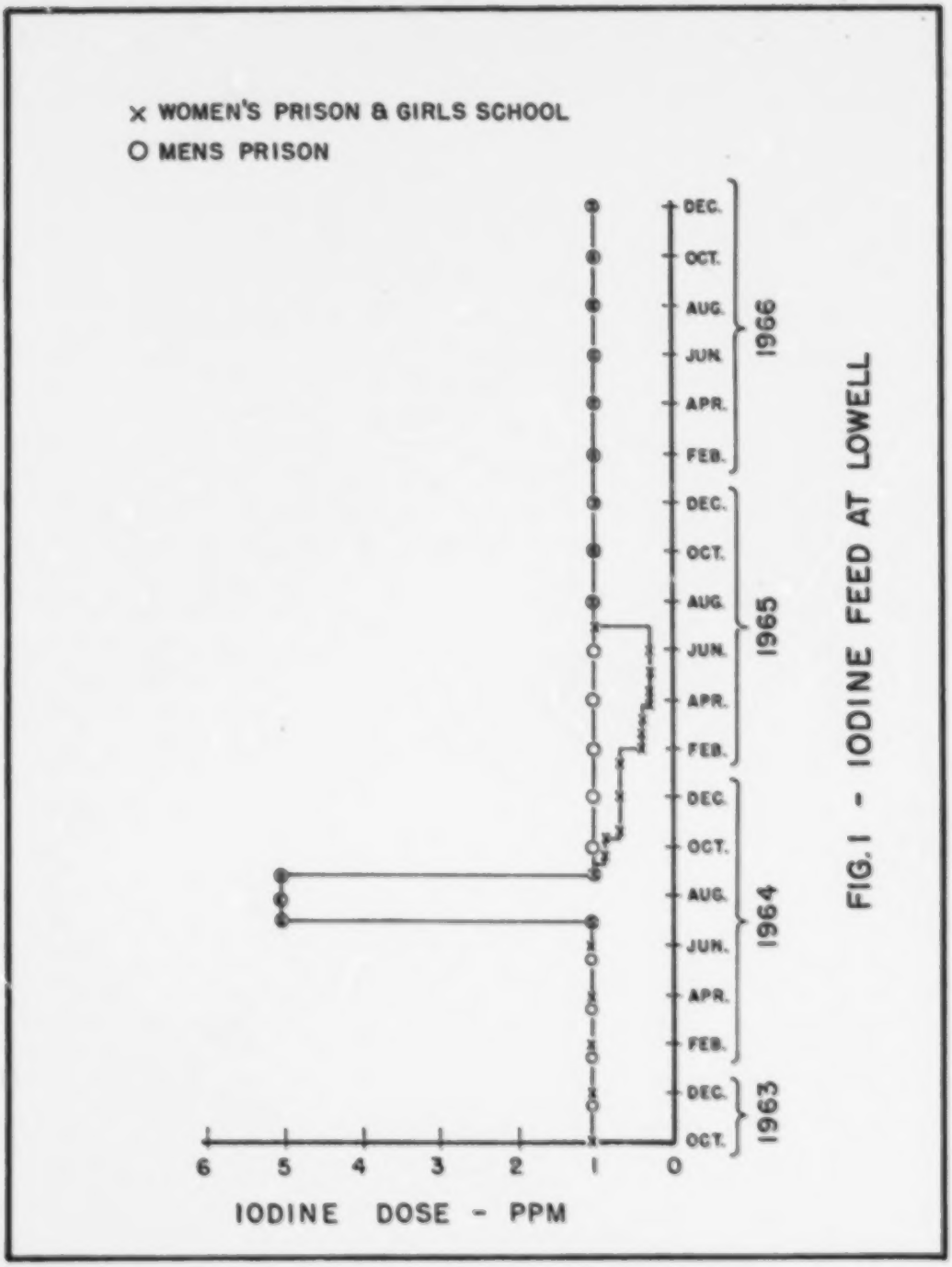


FIG. 1 - IODINE FEED AT LOWELL

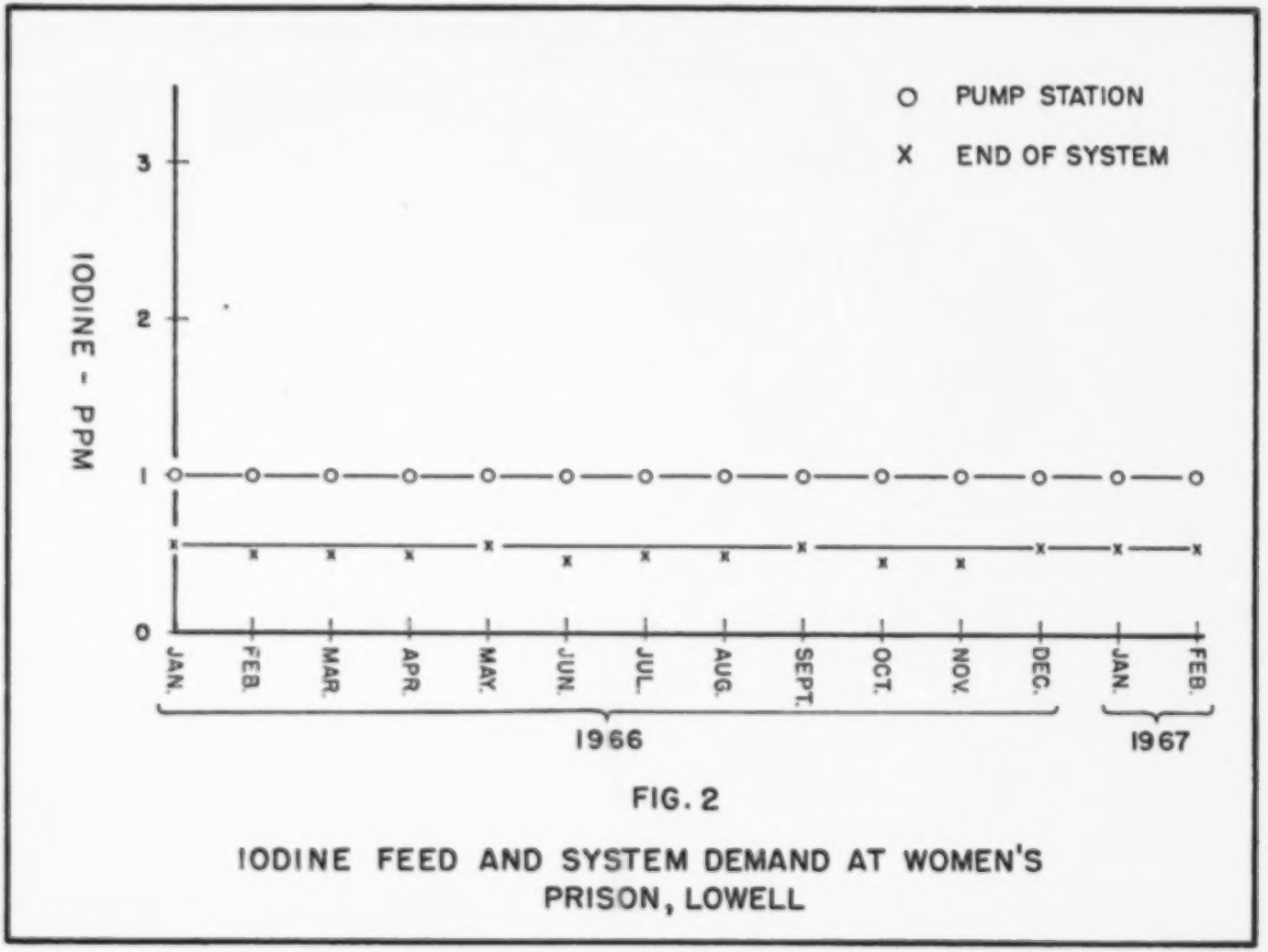


FIG. 2

IODINE FEED AND SYSTEM DEMAND AT WOMEN'S PRISON, LOWELL

1-3-66	PHELPS	−	+	−	+	−	−	−	−	−	−
1-5-66	FSBH	−	+	−	−	−	−	−	−	−	−
1-10-66	PHELPS	−	−	−	−	−	−	−	−	−	−
1-12-66	FSBH	−	+	−	−	−	−	−	−	−	−
1-17-66	PHELPS	+	+	−	+	−	−	−	−	−	−
1-18-66	FSBH	+	+	+	−	−	−	−	−	−	−
1-24-66	PHELPS	−	−	+	−	−	−	−	−	−	−
1-26-66	FSBH	−	+	+	+	−	−	−	−	−	−
1-31-66	PHELPS	−	+	−	−	−	−	−	−	−	−
2-2-66	FSBH	−	+	−	+	−	−	−	−	−	−
2-7-66	PHELPS	−	+	−	+	−	−	−	−	−	−
2-9-66	FSBH	+	−	−	−	−	−	−	−	−	−
2-14-66	PHELPS	−	+	−	−	−	−	−	−	−	−
2-15-66	FSBH	−	+	−	−	−	−	−	−	−	−
2-21-66	PHELPS	−	+	−	−	−	−	−	−	−	−
2-23-66	FSBH	−	+	−	−	−	−	−	−	−	−
2-28-66	PHELPS	−	+	−	−	−	−	−	−	−	−
		STA. 1	STA. 2	STA. 3	STA. 4	STA. 5	STA. 6	STA. 7	STA. 8	STA. 9	STA. 10

TREATED WATER

+ CONFIRMED

− NON-CONFIRMED

FIG. 3

COMPARISON OF BACTERIOLOGY

evidence of impaired thyroid function. The inorganic iodide in sera of these inmates averaged 6 μg/100 ml (normal 1 to 2 μg/100 ml) which is essentially the same concentration present, since the first observations after use of iodinated water for only one month. The radioactive iodine uptake by the thyroid glands continued to be low, but serum thyroxine concentrations remain normal. Thus, there is no evidence in these subjects that long-term use of an iodinated water supply has been deleterious to health.

4. Radioactive Iodine Tracer Studies

^{131}I excreted by test subjects during RAI uptake studies was traced from the effluent of the sewage treatment plant at the Florida Correctional Institution for Women to Well No. 2, which consistently shows the presence of a few coliform organisms. The maximum concentration of ^{131}I in the well water, which was reached two to three days after being administered to the test subjects, was well below the MPC (3×10^{-6} μCi/ml) set by the Florida State Board of Health. See Figure 4.

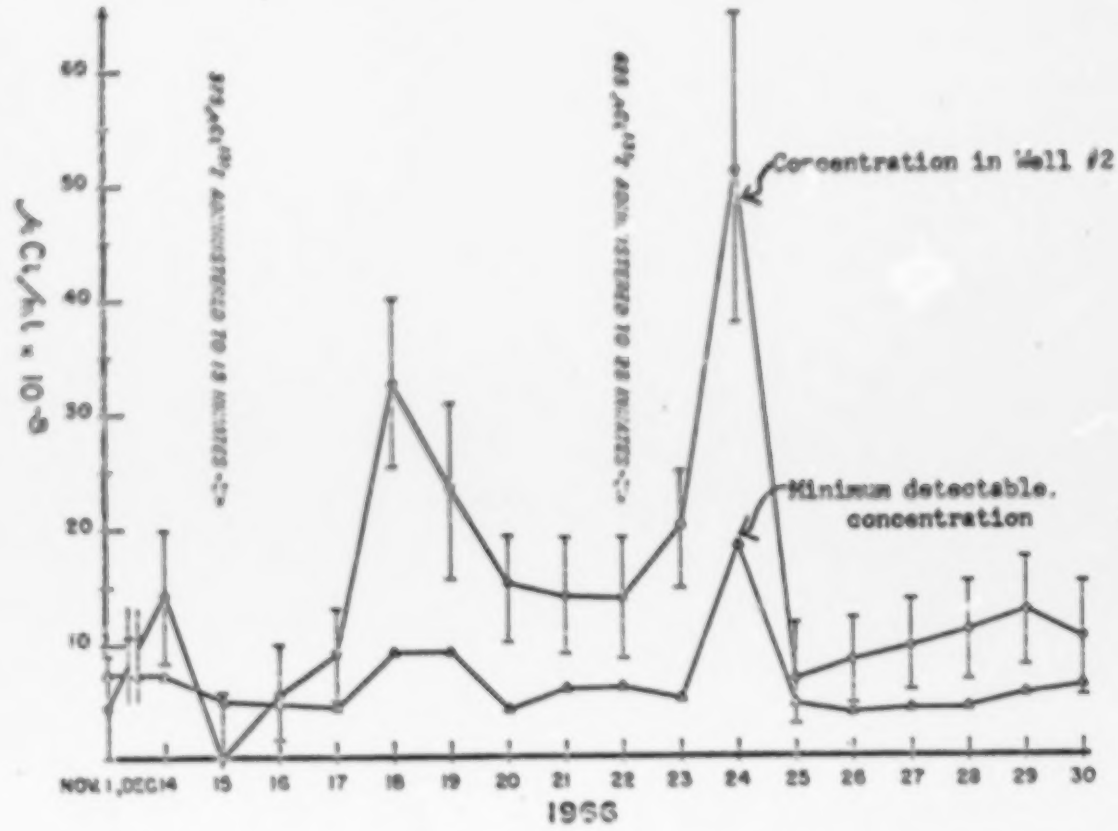


Fig. 4 - ^{131}I IN WATER FROM WELL NO. 2 (GIRLS SCHOOL, LOWELL, FLA.)

5. Effect of pH on an Iodinated Water.

The water supplied to the Lowell institutions has a pH of 7.4. However, the pH value of most chemically treated and stabilized supplies is usually substantially higher than that value. Most treated supplies will have pH values falling in the range pH 8.2 - 8.9, values in the low 9's are not uncommon and a few softening plants using the lime-soda process and stabilizing with polyphosphates deliver a softened effluent whose pH may be as high as 10. It has appeared desirable, therefore, that a study be made of the effect of pH on an iodinated water. Such a study has been in progress since January 20, 1967, in order to determine the effect of higher pH values on:

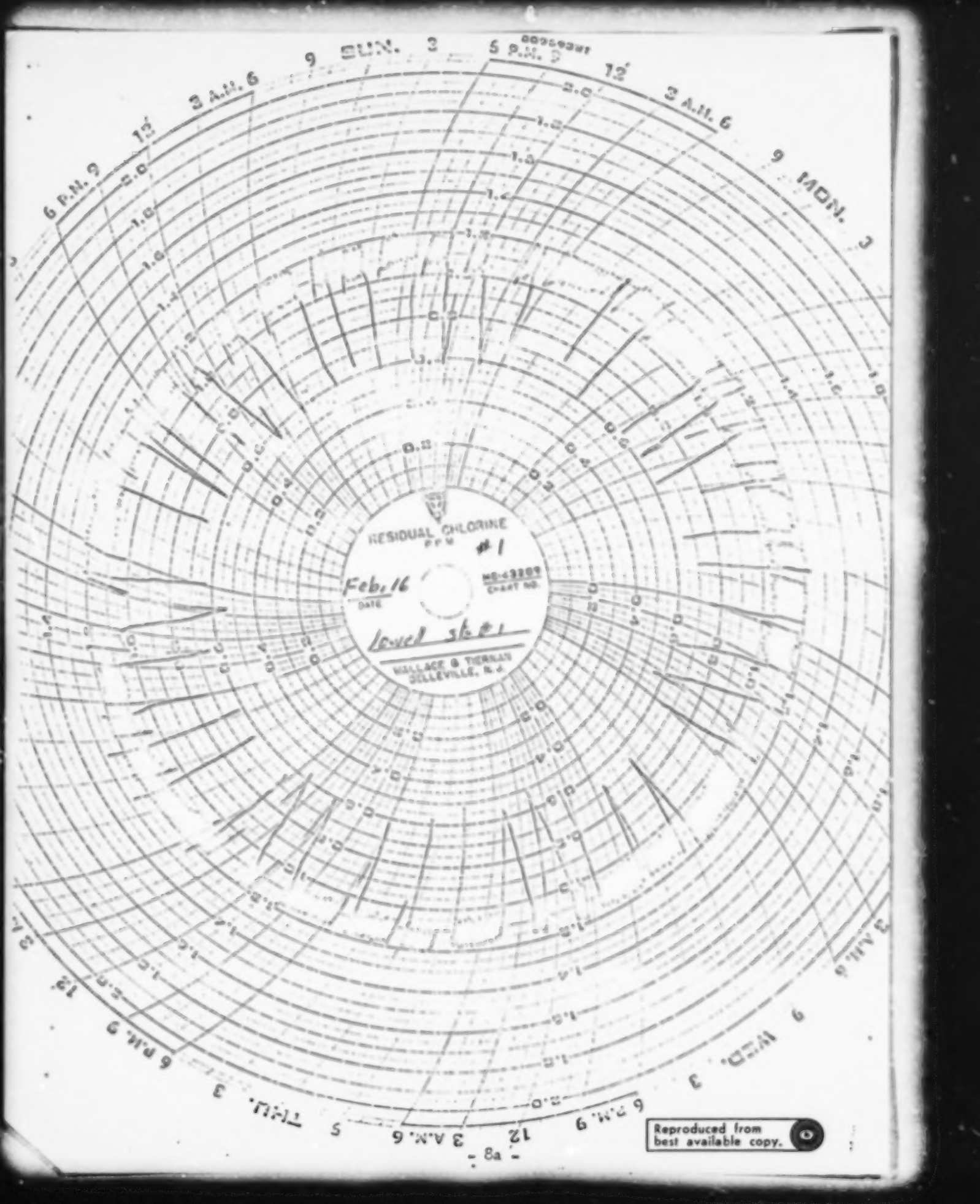
(a) The stability and persistence of an iodine residual.
(b) The conversion of iodine or iodide to iodate.
(c) The bactericidal effectiveness of an iodine residual.

The pH of the water is raised by the continuous addition of a solution of NaOH and the formation of $CaCO_3$ scale prevented by the continuous addition of a dosage of 1 ppm of sodium hexametaphosphate. Throughout the study the usual dosage of 1.0 $\pm$ .05 ppm I_2 is being added.

(a) Iodine demand is determined by comparing the values on the iodine recorder charts in the pump station with the residuals provided by a second recorder located at the sewage treatment plant at the end of the distribution system. Chart 1 is a typical weekly chart from the pumping station recorder and charts 2 and 3 are typical charts from the recorder in the sewage treatment plant for water pH values of 8.5 and 9.0 respectively.

(b) Additional residual determinations are made daily at Cottage 4, at the new detention hall, and at the sewage plant, using both the new iodine test kit and an amperometric titrator. At these points iodine, iodide and iodate determinations are made on each sample. The study was begun at these pH values since the data were needed in preparing for the more extensive Gainesville test begun on February 23. The entire range from pH 8.0 - 9.5 will be covered twice in increments of 0.5 pH unit. Initial data for pH 8.5 and 9.0 are shown in Figure 5 and Tables 1 and 2 . At these pH values, pH has little effect on the iodine demand of the water and iodate formation is not significant.

(c) Samples for bacteriological analysis are collected on Monday, Tuesday, Wednesday and Thursday of each week at four widely spaced locations in the system. The data in Tables 3 and 4 show that no coliforms have been found in any sample during the test except in the samples collected on Monday, January 30. The pump was placed in service during that day and all samples collected on Tuesday, January 31 and all subsequent samples have contained no coliforms. This constitutes positive evidence of the ability of a 1.0 ppm residual to immediately and completely disinfect a polluted water supply. Well No. 2, which practically always confirms, was in use.



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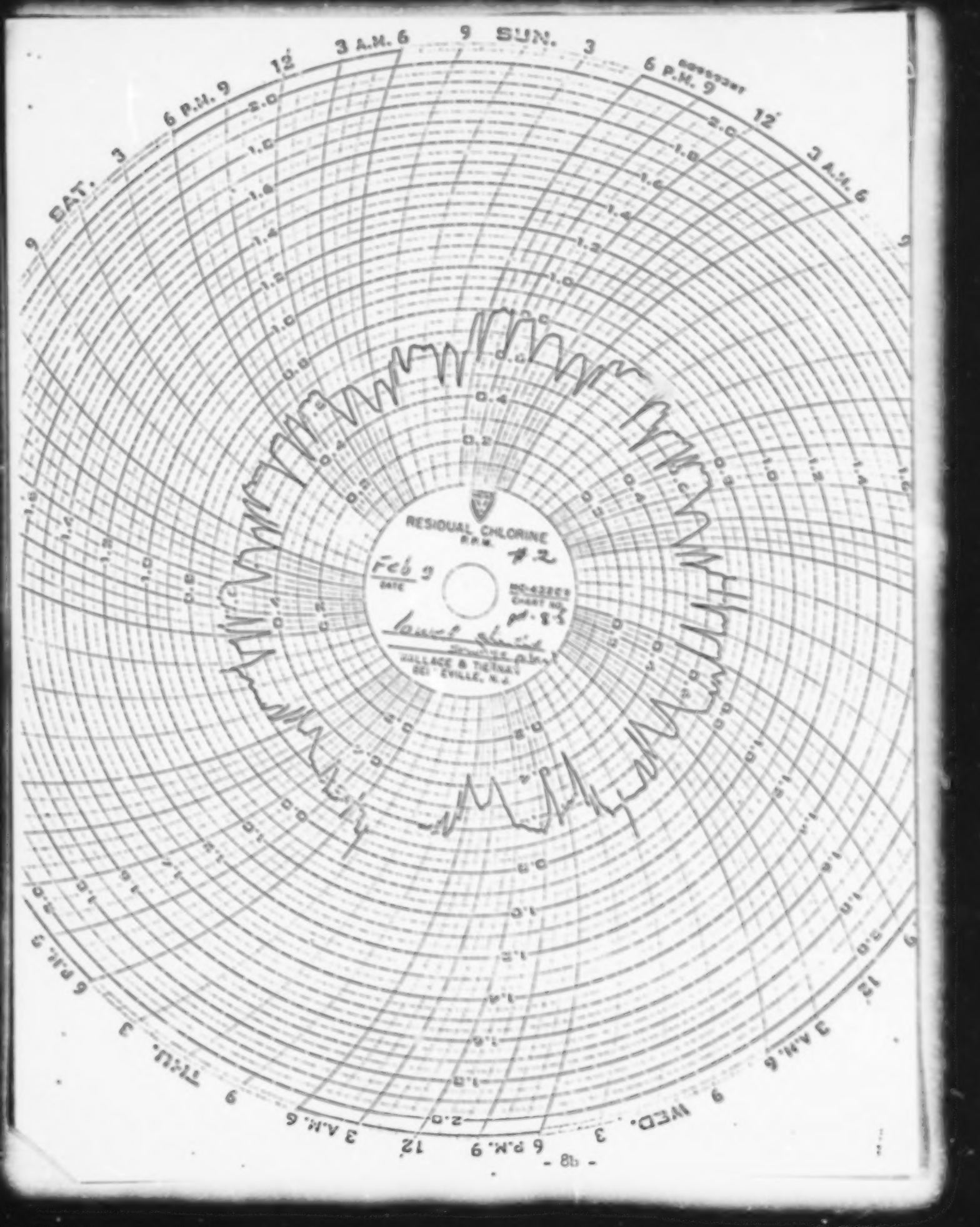
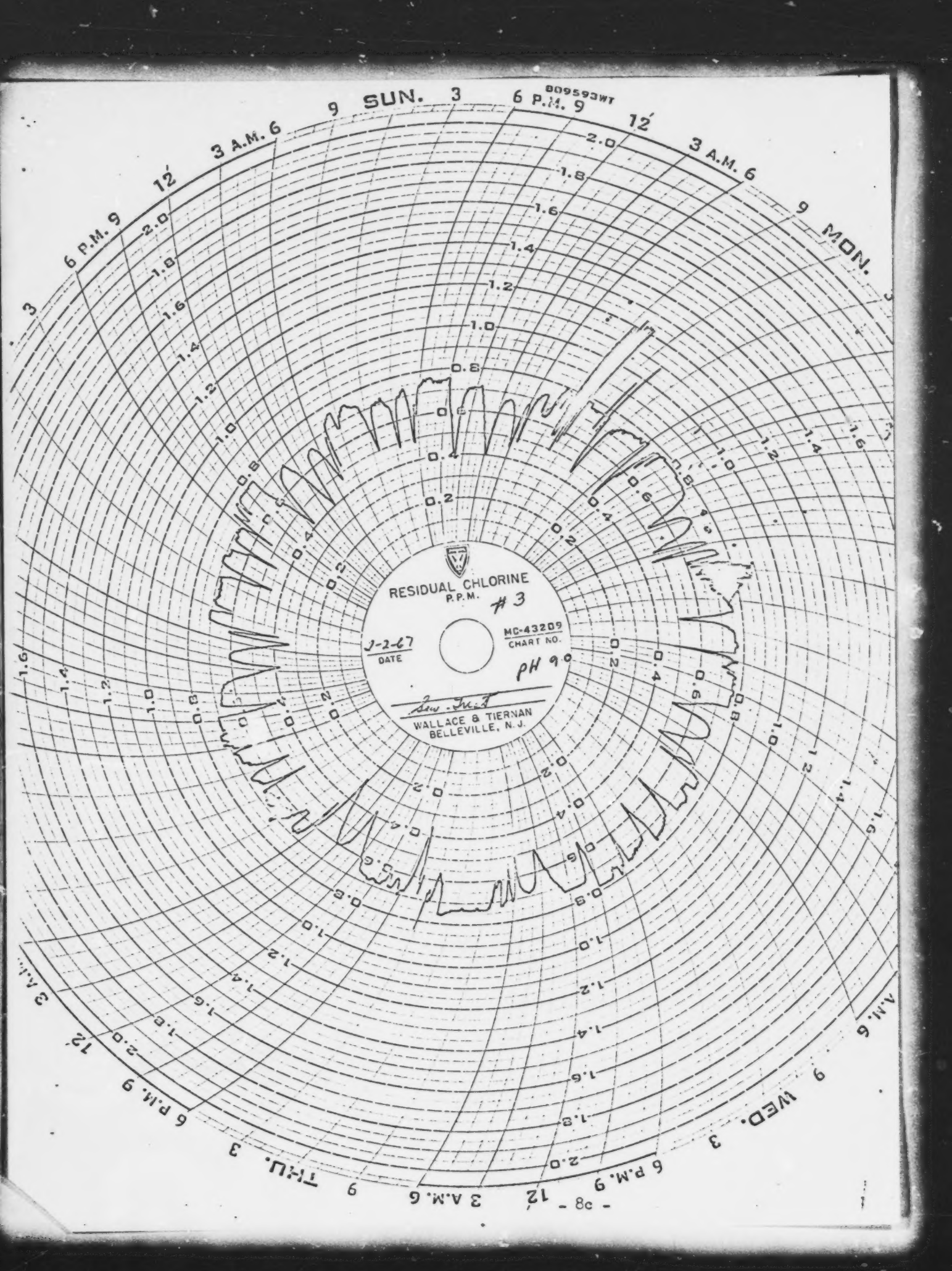

SUN.
MON.
TUES.
WED.
THUR.
FRI.
SAT.
3 A.M.
6 P.M.
12
RESIDUAL CHLORINE
P.P.M.
#2
Feb 9
DATE
CHART NO.
M-83
WALLACE & TIERNAN
BELLEVILLE, N.J.


809593WT
SUN.
MON.
TUE.
WED.
3 A.M.
6 P.M.
12
9
3
6
RESIDUAL CHLORINE
P.P.M.
#3
1-2-67
DATE
MC-43209
CHART NO.
pH 9.0
WALLACE & TIERNAN
BELLEVILLE, N.J.

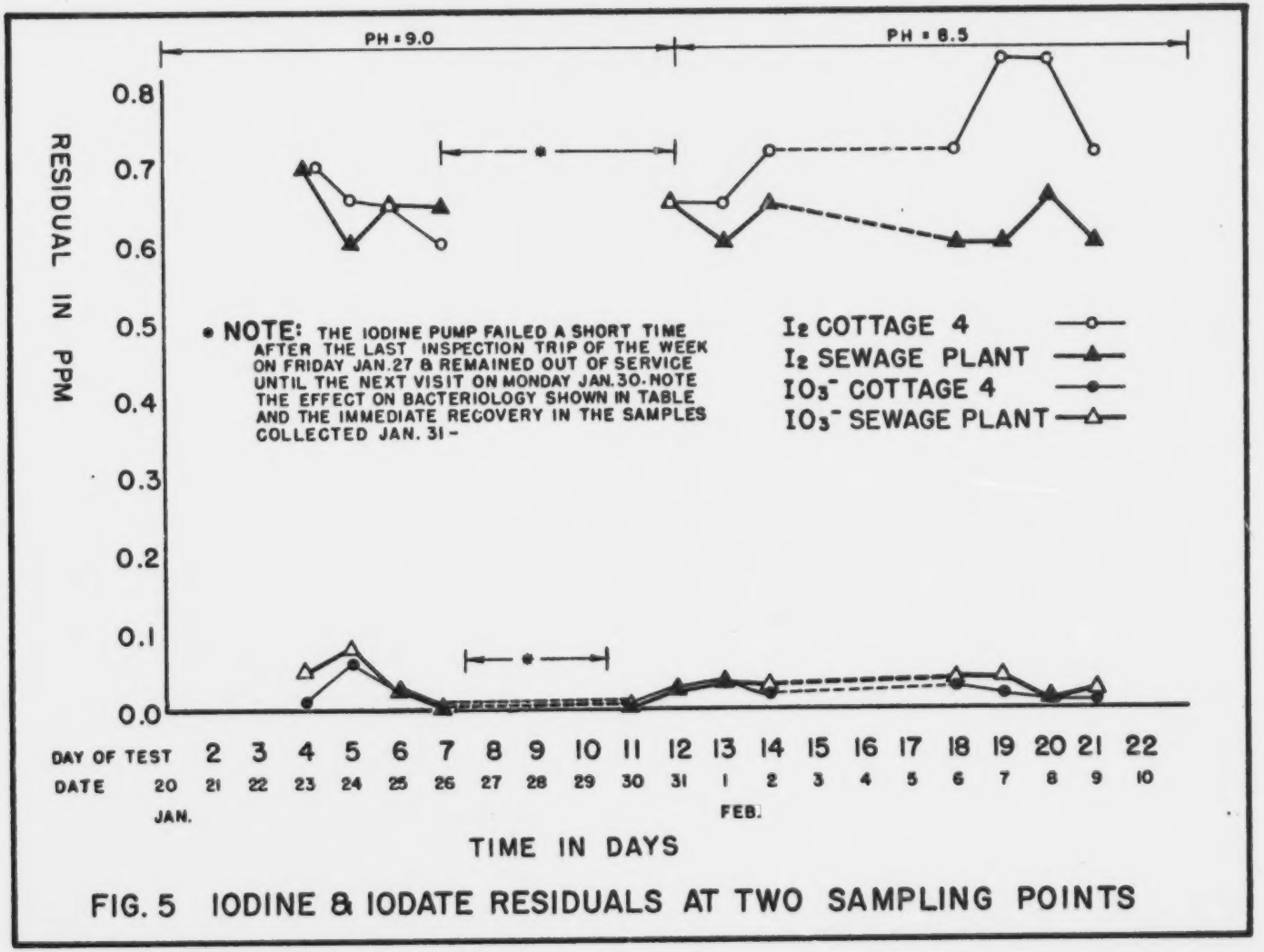

PH = 9.0
PH = 8.5
RESIDUAL IN PPM
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
• NOTE: THE IODINE PUMP FAILED A SHORT TIME AFTER THE LAST INSPECTION TRIP OF THE WEEK ON FRIDAY JAN. 27 & REMAINED OUT OF SERVICE UNTIL THE NEXT VISIT ON MONDAY JAN. 30. NOTE THE EFFECT ON BACTERIOLOGY SHOWN IN TABLE AND THE IMMEDIATE RECOVERY IN THE SAMPLES COLLECTED JAN. 31 -
I2 COTTAGE 4
I2 SEWAGE PLANT
IO3- COTTAGE 4
IO3- SEWAGE PLANT
DAY OF TEST 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
DATE 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10
JAN.
FEB.
TIME IN DAYS

FIG. 5 IODINE & IODATE RESIDUALS AT TWO SAMPLING POINTS

Table 1

Iodate Determined at Two Sampling Points

Date	pH	Cottage No. 4 ppm as I_2	Sewage Plant ppm as I_2
Jan. 30	9.0	0.00	0.00
Jan. 31	9.0	0.01	0.02
Feb. 1	9.0	0.02	0.02
Feb. 2	9.0	0.02	0.03
Feb. 6	8.5	0.04	0.04
Feb. 7	8.5	0.02	0.03
Feb. 8	8.5	0.02	0.02
Feb. 9	8.5	0.02	0.03

Table 2

Iodine, Iodide, and Iodate Residuals at Two Sampling Points

Date	pH	Cottage No. 4*			Sewage Plant*		
		I_2	I^-	IO_3^-	I_2	I^-	IO_3^-
Jan. 23	9.0	0.70	.0.30	0.01	0.70	0.30	0.05
Jan. 24	9.0	0.66	0.34	0.06	0.60	0.10	0.08
Jan. 25	9.0	0.66	0.06	0.02	0.65	0.07	0.02
Jan. 26	9.0	--	--	--	--	--	--
Jan. 30#	9.0	0.00	0.00	0.00	0.00	0.00	0.00
Jan. 31	9.0	0.66	0.06	0.01	0.66	0.00	0.01
Feb. 1	9.0	0.66	0.06	0.02	0.60	0.18	0.02
Feb. 2	9.0	0.72	0.06	0.02	0.66	0.06	0.03
Feb. 6	8.5	0.72	0.00	0.04	0.60	0.00	0.04
Feb. 7	8.5	0.84	0.06	0.02	0.60	0.00	0.03
Feb. 8	8.5	0.84	0.06	0.02	0.66	0.06	0.03
Feb. 9	8.5	0.72	0.06	0.02	0.60	0.06	0.03
Feb. 13	8.5	0.66	0.00	0.03	0.60	0.06	0.03
Feb. 14	8.5	0.84	0.12	0.01	0.66	0.06	0.02
Feb. 15	8.5	0.72	0.06	0.01	0.66	0.06	0.02

*Using iodine kit.

#Iodine feed pumps were off due to mechanical failure.

Table 3

Bacteriological Data Feb. 2-7, 1967

pH 8.5

Date	Station#	Coliform Study MPN	MF		SPC
Feb. 2	1	<2.0	0	<1	130
	2	<2.0	0	<1	3
	3	<2.0	0	<1	4
	4	<2.0	0	<1	140
Feb. 6*	1	<2.0	0	<1	9300
	2	<2.0	0	<1	3
	3	<2.0	0	<1	14
	4	<2.0	0	<1	4
Feb. 7	1	<2.0	0	<1	6400
	2	<2.0	0	<1	46
	3	<2.0	0	<1	240
	4	<2.0	0	<1	28

#1 - Administration Building
2 - Sewage Plant
3 - Cottage No. 4
4 - Detention Hall

*No samples collected during the weekends.

Table 4

Bacteriological Data Jan. 23 - Feb. 1, 1967

pH 9.0

Date	Station#	Coliform Study MPN	Coliform Study MF	SPC
Jan. 23	1	<2.0	0 < 1	200
	2	<2.0	0 < 1	7
	3	<2.0	0 < 1	5
	4	<2.0	0 < 1	22
Jan. 24	1	<2.0	0 < 1	190
	2	<2.0	0 < 1	2
	3	<2.0	0 < 1	4
	4	<2.0	0 < 1	16
Jan. 25	1	<2.2	0 < 1	360
	2	<2.2	0 < 1	3
	3	<2.2	0 < 1	3
	4	<2.2	0 < 1	7
Jan. 26	1	<2.0	0 < 1	81
	2	<2.0	0 < 1	5
	3	<2.0	0 < 1	6
	4	<2.0	0 < 1	3
Jan. 31	1	<2.0	< 1	130
	2	<2.0	< 1	4
	3	<2.0	< 1	8
	4	<2.0	< 1	3

Table 4 - continued

Date	Station#	Coliform Study MPN	MF	SPC
Feb. 1	1	<2.0	<1	130
	2	<2.0	<1	3
	3	<2.0	<1	4
	4	<2.0	<1	140

#1 - Administration Building
2 - Sewage Plant
3 - Cottage No. 4
4 - Detention Hall

B. Baseline Studies at Gainesville

The City of Gainesville is located over one of the most productive and extensive ground water bearing formations in the continental United States. This formation is called the Floridan Aquifer and underlies practically all of the peninsula of Florida. In the Gainesville area it is composed of limestones and dolomites which extend to a depth of several thousand feet. This aquifer is the source of water supply for the City.

Within the city limits the Floridan Aquifer is covered by sands and clays which extend from the surface to approximately one hundred feet in depth. The sand and clay beds thin out to the southwest and increase in thickness to the northeast.

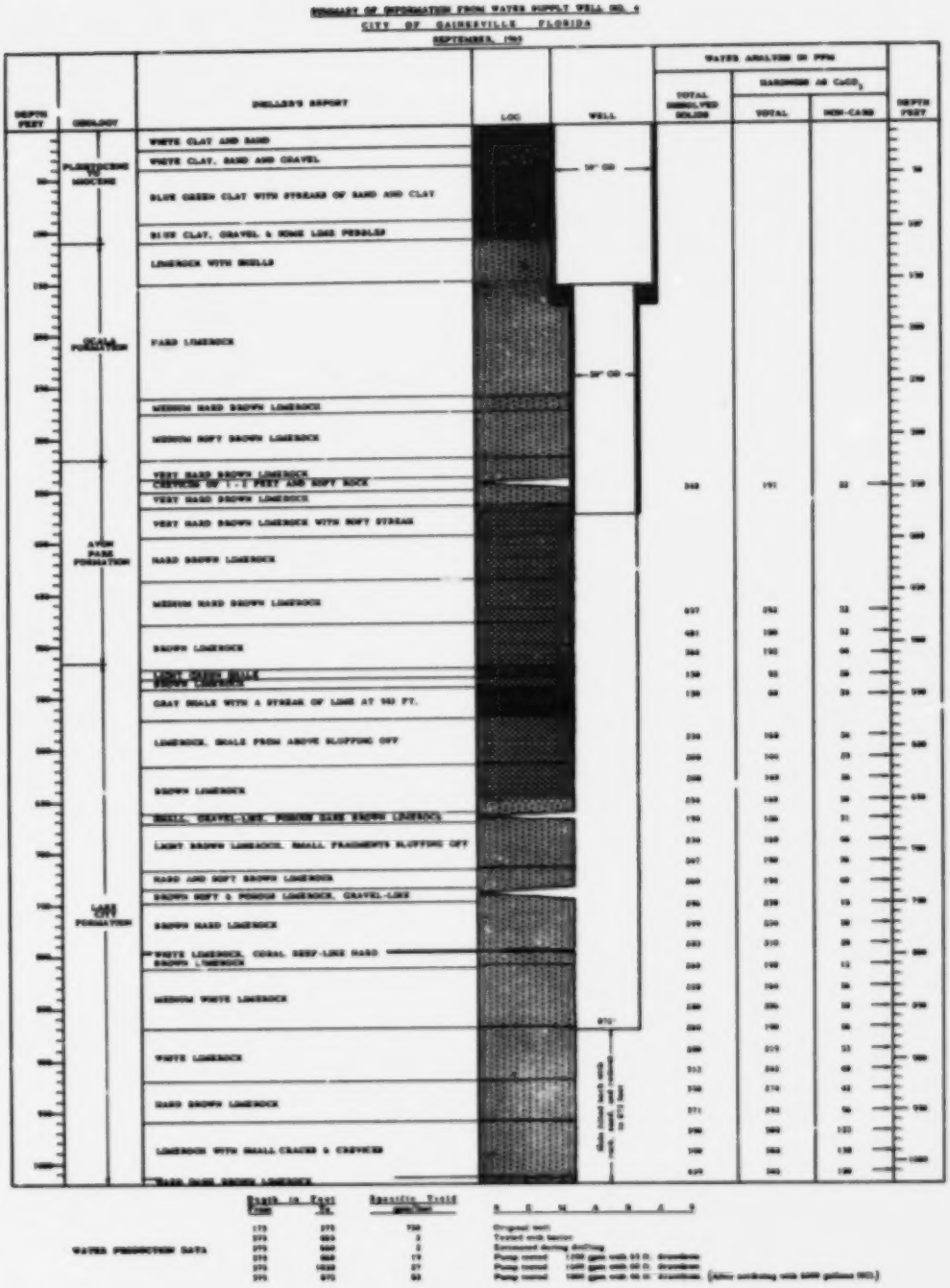
Exploratory work conducted in the area indicates that the characteristics of the Floridan Aquifer are substantially the same in the Gainesville area as those encountered in Well No. 4. These characteristics are as follows:

a. The aquifer begins at approximately 100 to 150 feet in depth.
b. It extends beyond 1,020 feet in depth.
c. The permeability of the aquifer varies considerably and is actually caused by several beds of extremely cavernous and permeable limestones separated by other beds of dense and practically impermeable dolomites and limestones.
d. The most cavernous formations are found between 300 and 350 feet and also at shallower depths (100 to 200 feet).
e. Permeable beds are again found from 650 to 800 feet and from 960 to at least 1,020 feet.
f. Between 350 and 650 feet there are layers of practically impervious limestones and dolomites which, at least in the City wells, impede direct communication between the top and bottom permeable strata.
g. The water in the top part (100-350 feet) of the Floridan Aquifer is moderately hard (190 ppm as $CaCO_3$), low in chlorides (10 ppm as Cl), and low in sulfates (30-40 ppm as SO_4). The quality of the water in these strata remained relatively constant until recent years. The quality has subsequently deteriorated during periods of intense rainfall. Pollution with surface waters has become evident during those periods.
h. The water between 650 and 850 feet in depth is slightly harder (220 ppm), slightly higher in chlorides (26 ppm), with approximately the same amount of sulfates. So far, it has remained uncontaminated.

Figure 6 is a graphical representation of data derived from the drilling and testing program of City Well No. 4. Information in the column "Geology" has been compiled from data of the Florida Geological Survey.

The piezometric surface in the top part of the Floridan Aquifer slopes toward the center of the city where 7 wells comprising the City's well field are located.

Fig. 6 -


SUMMARY OF INFORMATION FROM WATER SUPPLY WELL NO. 4
CITY OF GAINESVILLE FLORIDA
SEPTEMBER, 1947
DEPTH FEET
GEOLOGY
DRILLER'S REPORT
LOG
WELL
WATER ANALYSIS IN PPM
TOTAL DISSOLVED SOLIDS
HARDNESS AS CaCO3
TOTAL
NON-CARB
DEPTH FEET
PLEISTOCENE TO MIOCENE
OCALA FORMATION
AVON PARK FORMATION
LAKE CITY FORMATION
WHITE CLAY AND SAND
WHITE CLAY, SAND AND GRAVEL
BLUE GREEN CLAY WITH STREAKS OF SAND AND CLAY
BLUE CLAY, GRAVEL & SOME LOOSE PEBBLES
LIMEROCK WITH SHELLS
HARD LIMEROCK
MEDIUM HARD BROWN LIMEROCK
MEDIUM SOFT BROWN LIMEROCK
VERY HARD BROWN LIMEROCK
CREVICE OF 1 - 1 FEET AND SOFT ROCK
VERY HARD BROWN LIMEROCK
VERY HARD BROWN LIMEROCK WITH SOFT STREAK
HARD BROWN LIMEROCK
MEDIUM HARD BROWN LIMEROCK
BROWN LIMEROCK
LIGHT GREEN BLUE
BROWN LIMEROCK
GRAY SHALE WITH A STREAK OF LIME AT 910 FT.
LIMEROCK, SHALE FROM ABOVE SLOPPING OFF
BROWN LIMEROCK
SHELL, GRAVEL-LIKE, MEDIUM HARD BROWN LIMEROCK
LIGHT BROWN LIMEROCK, SMALL FRAGMENTS SLOPPING OFF
HARD AND SOFT BROWN LIMEROCK
BROWN SOFT & POROUS LIMEROCK, GRAVEL-LIKE
BROWN HARD LIMEROCK
WHITE LIMEROCK, CORAL REEF-LIKE HARD
BROWN LIMEROCK
MEDIUM WHITE LIMEROCK
WHITE LIMEROCK
HARD BROWN LIMEROCK
LIMEROCK WITH SMALL CRACKS & CREVICES
Hole filled back with rock, sand and cement to 970 feet
WATER PRODUCTION DATA
Depth in Feet From
To
Specific Yield gpm/ft
Original test
Tested with bailer
Enlargement during drilling
Pump tested
Pump tested
Pump tested

In recent years sewage pollution in Wells 4 and 6 became evident, making it necessary to deepen these wells and case out the upper permeable strata of the aquifer to eliminate the contamination.

Two possible sources of sewage pollution exist on the periphery of the City, Lake Alice to the west and Alachua sink to the south, each about 3 miles from the City's well field. Effluent from the campus sewage treatment plant empties into Lake Alice which is drained by two 24 inch diameter drainage wells penetrating the upper permeable strata of the Floridan Aquifer. Alachua Sink receives the effluent from the City's sewage treatment plant and drains approximately 30,000 acres of pasture land.

Sample points were selected to first establish the baseline iodide concentration in the water prior to continuous iodination of the City's water, and second to determine the source and extent of sewage pollution in the Floridan Aquifer near the City of Gainesville. The wells selected are pumped frequently if not continuously so that water which is representative of the Aquifer could be obtained. City Well No. 3 was selected as a typical well extending only into the upper permeable strata, and No. 6 as typical of wells extending to the lower permeable strata, with the upper strata cased out. Contours of the piezometric surface in the top part of the Floridan Aquifer and the relative locations of all sample points are given in Figure 7 .

Samples are collected periodically from each sampling point for chemical and bacteriological determinations. At the beginning of the test period, 29 different types of analyses were made on each sample. However, a review of the data revealed that several determinations could be omitted without hampering the objectives of the study, as seen in Table 5. From these chemical and bacteriological determinations it is hoped that the magnitude and extent of organic pollution can be determined.

Some of the data obtained thus far are presented in Figures 8-14 . Collectively, these data suggest that pollution exists to the south and west of the present well field and indicates that the City's new well field should be located northeast of the City. These data further suggest that the drainage wells at Lake Alice are responsible for the pollution found in the University of Florida Well, City Well No. 6 and to some extent City Well No. 3. Confirmation or rejection of these hypotheses will be obtained by a change in baseline iodide levels after iodination of the City's water supply.

It should be noted that both the upper and lower permeable strata of the Floridan Aquifer contain organic pollutants with the lower permeable strata apparently receiving polluted water from two drainage wells at Lake Alice. A schematic diagram showing a possible path for pollutants through three wells located near the University Teaching Hospital is shown in Figure 15.

Bacteriological quality of water from various parts of the distribution system before and after iodination will be initially used as criteria for

Table 5

Analytical Data Sheet

Sample # _____ Location _____ Date: From_____To_____

Date & time begin_____; end_____ No. of hours_____

Meter reading begin _____; end _____

Pumping rate or flow of stream_____

Analysis	Result	Analysis	Result
pH		CAE	
COD[x]		CCE	
BOD[x]		Ether insolubles[x]	
Free NH_3-N		Water solubles[x]	
Albuminoid NH_3-N		Neutrals[x]	
Nitrite		Weak acids[x]	
Nitrate		Strong acids[x]	
Iodide		Bases[x]	
H_2S[x]		Total	
Alkalinity[x]		Bacteriology	
Total hardness[x]		MPC (coliform)/100 ml	
Chloride		MPC (non c.)/100 ml	
Organic Color		SPC	
ABS[x]			
Phosphate			
Halogen demands			
Cl_2			
I_2[x]			

[x]After evaluation of the initial data these analyses were discontinued.

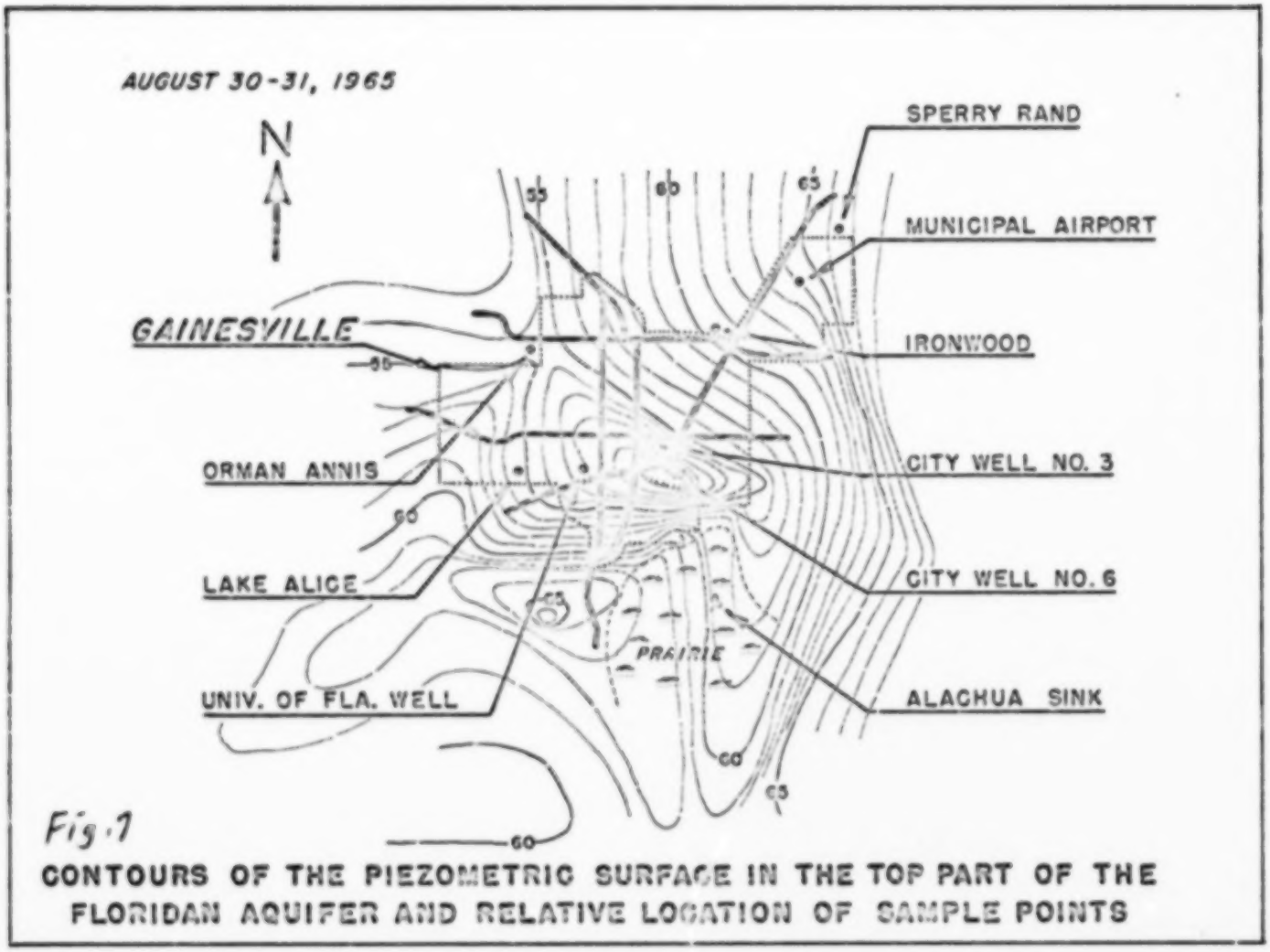


Fig. 1

CONTOURS OF THE PIEZOMETRIC SURFACE IN THE TOP PART OF THE FLORIDAN AQUIFER AND RELATIVE LOCATION OF SAMPLE POINTS

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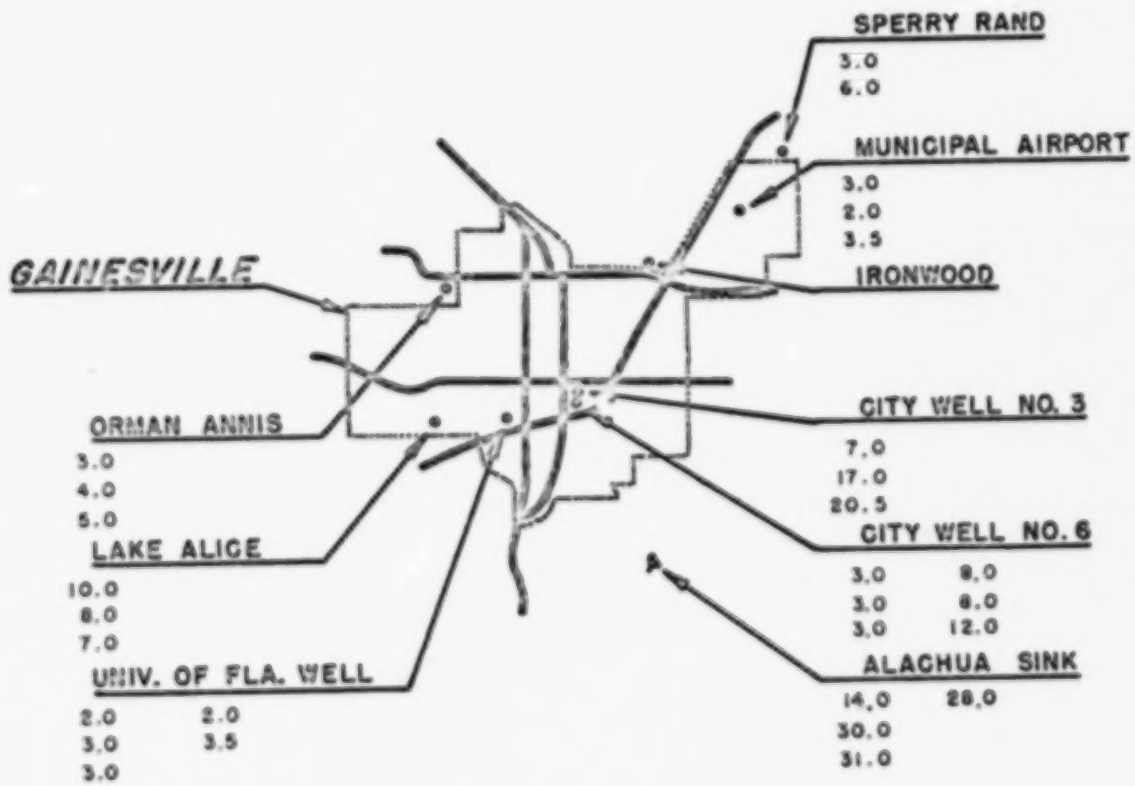


Fig. 8- IODINE DEMAND OF WATER IN THE GAINESVILLE AREA (ppm)
NOV. 1966-JAN. 1967

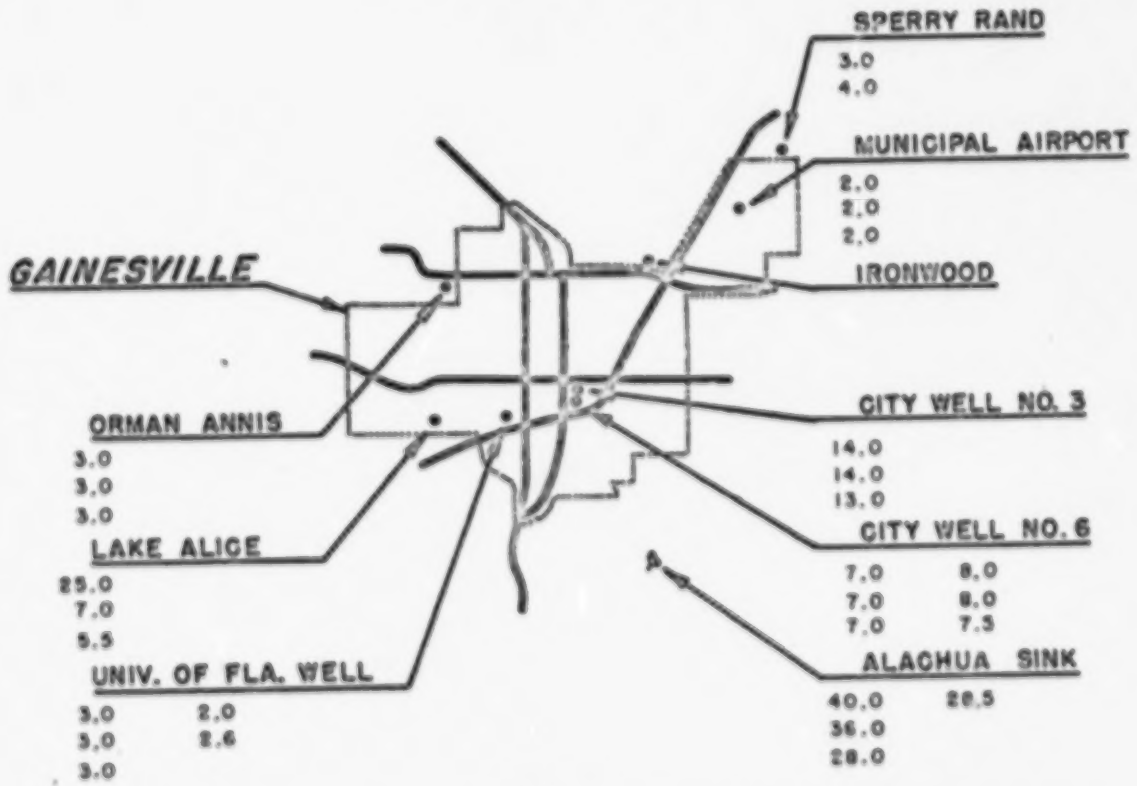


Fig. 9- CHLORINE DEMAND OF WATER IN THE GAINESVILLE AREA (ppm)
NOV. 1966 - JAN. 1967

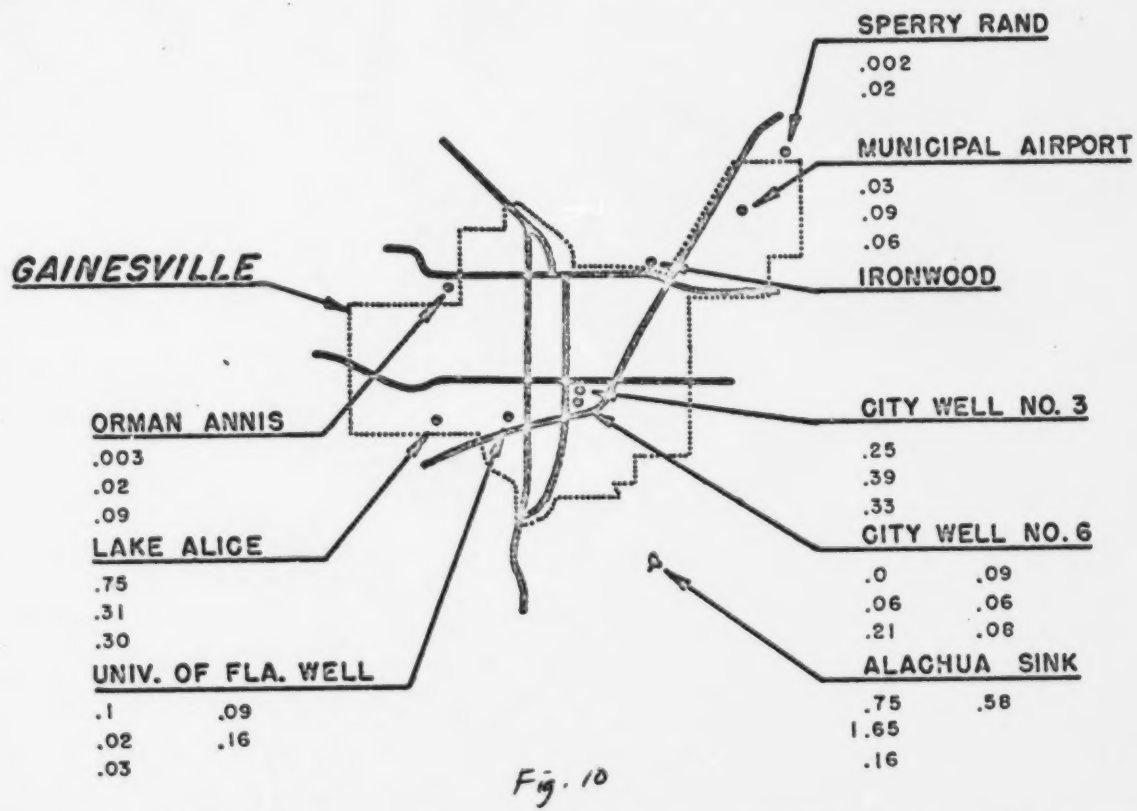


Fig. 10

ALBUMINOID AMMONIA N IN WATER WITHIN THE GAINESVILLE AREA (ppm as N)

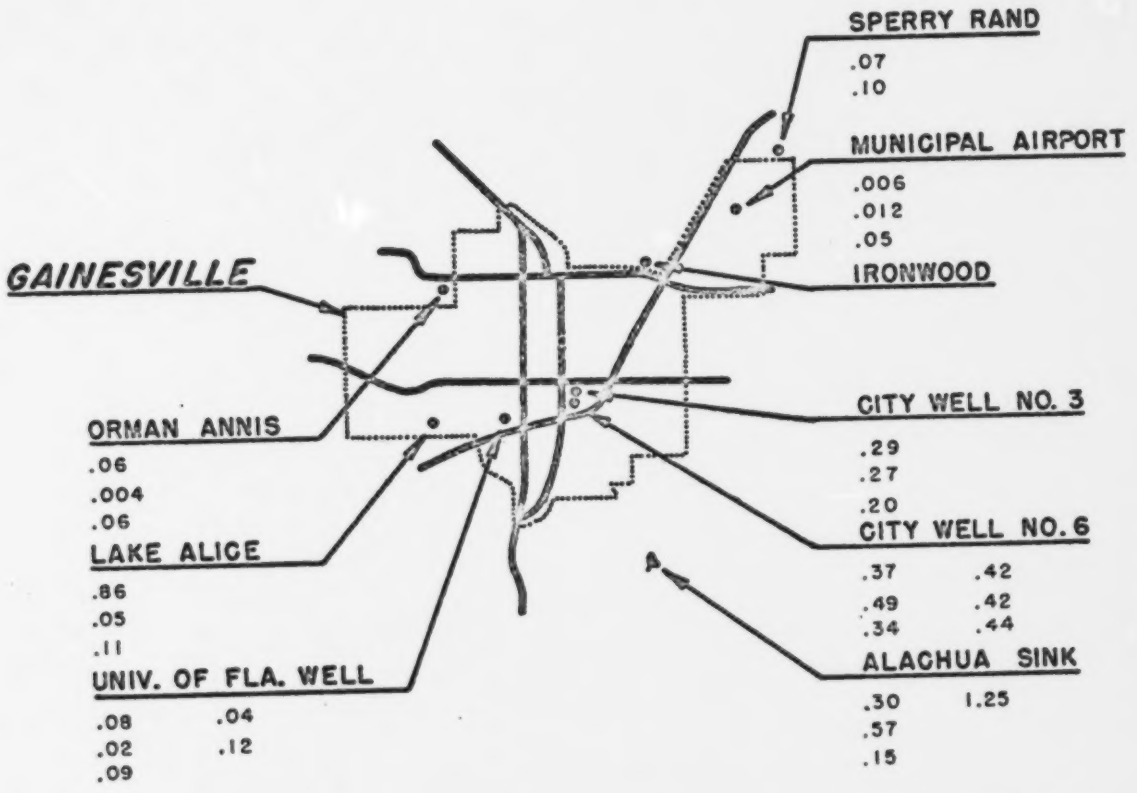


Fig. 11- FREE AMMONIA N IN WATER WITHIN THE GAINESVILLE AREA (ppm AS N) NOV. 1966 – JAN. 1967

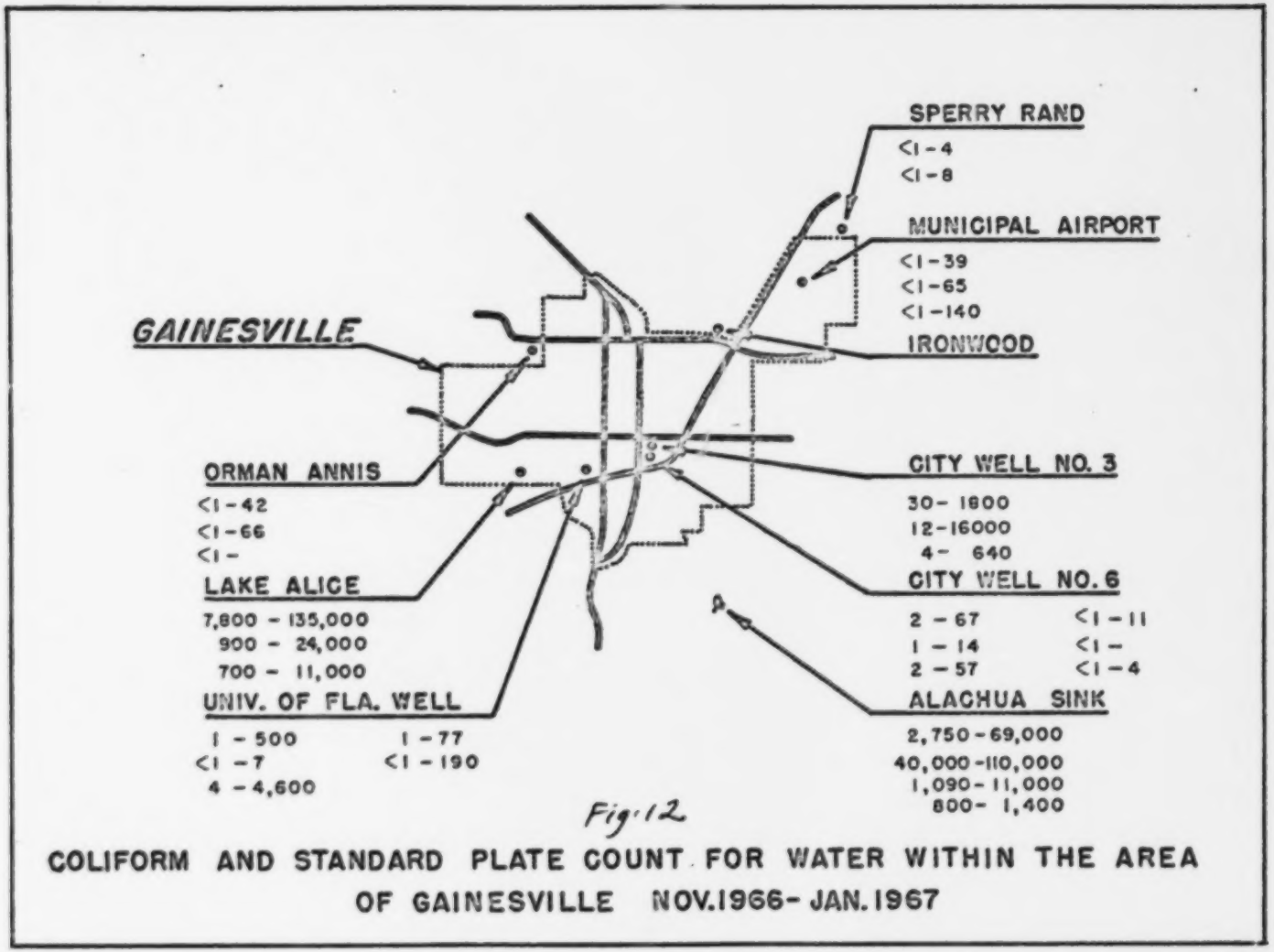


Fig. 12

COLIFORM AND STANDARD PLATE COUNT FOR WATER WITHIN THE AREA OF GAINESVILLE NOV. 1966 - JAN. 1967

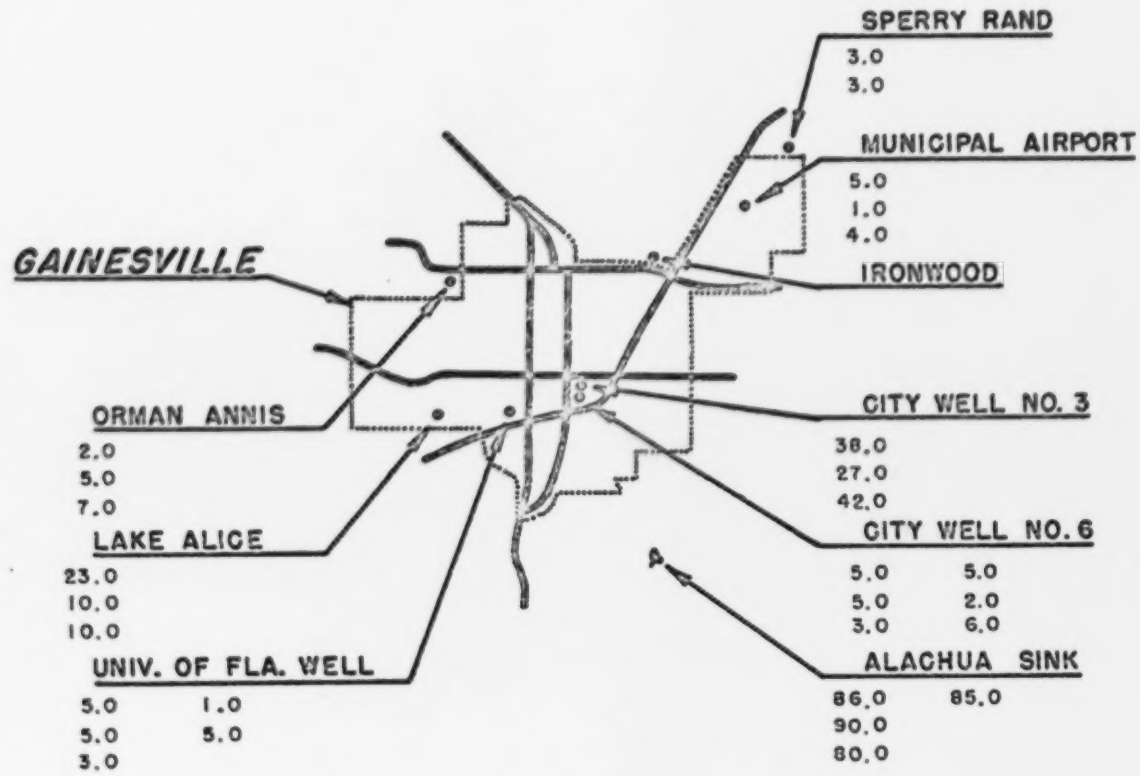


Fig 13-COLOR OF WATER IN THE GAINESVILLE AREA (UNITS) NOV. 1966-JAN. 1967

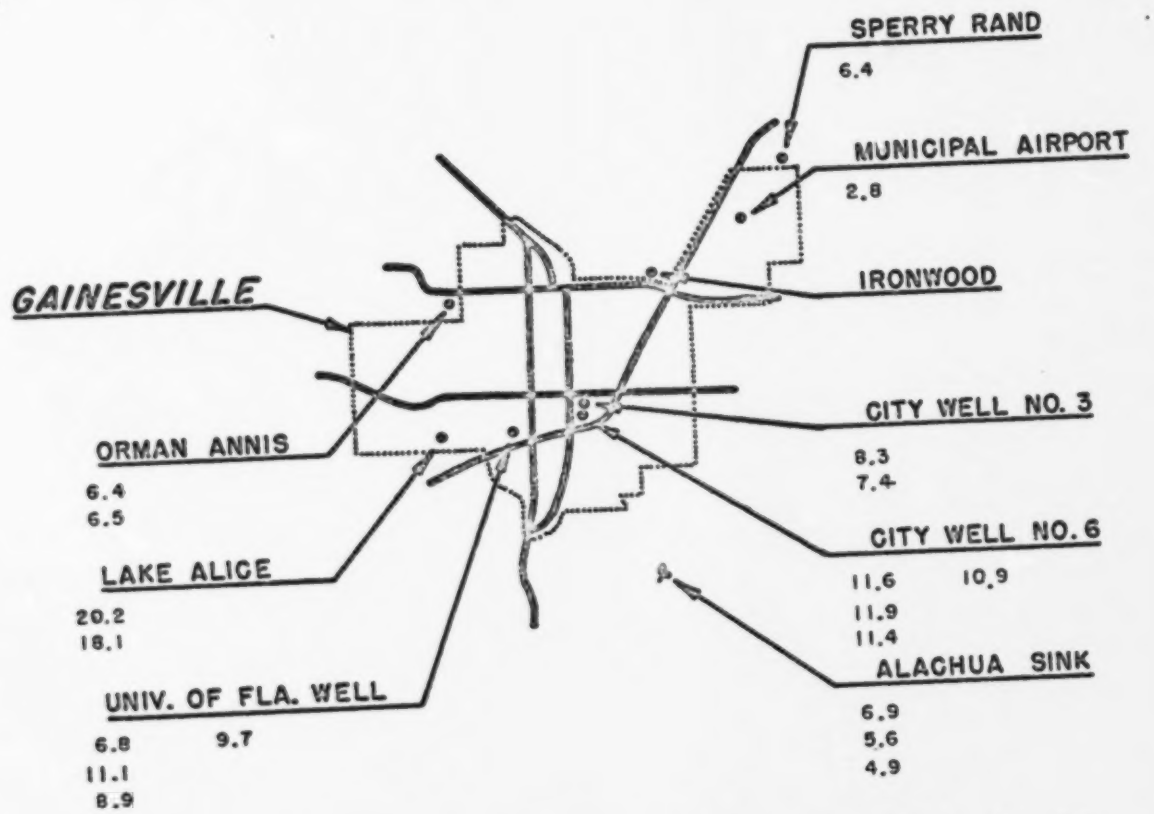


Fig. 11 IODIDE CONTENT OF WATER IN THE GAINESVILLE AREA (ppb)
NOV. & DEC. 1966

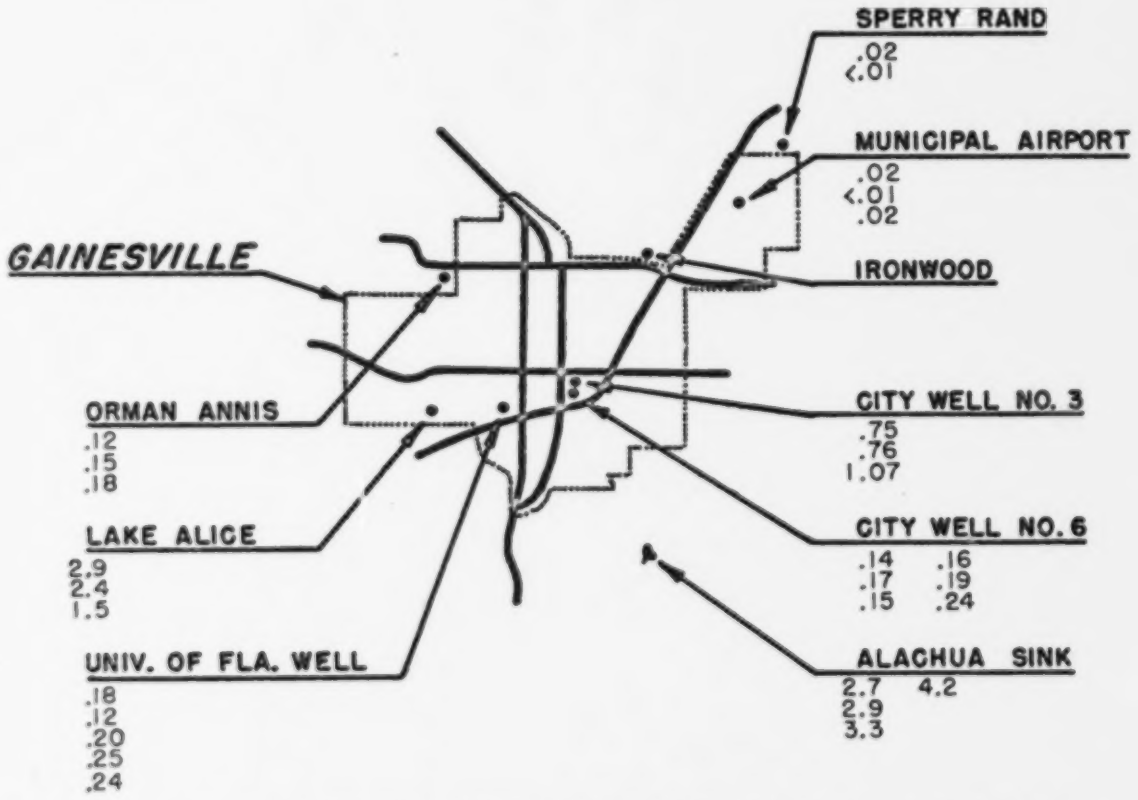


Fig. 14-A. TOTAL PHOSPHATE IN WATER WITHIN THE GAINESVILLE AREA (PPM AS PO_4) NOV. 1966 - JAN. 1967

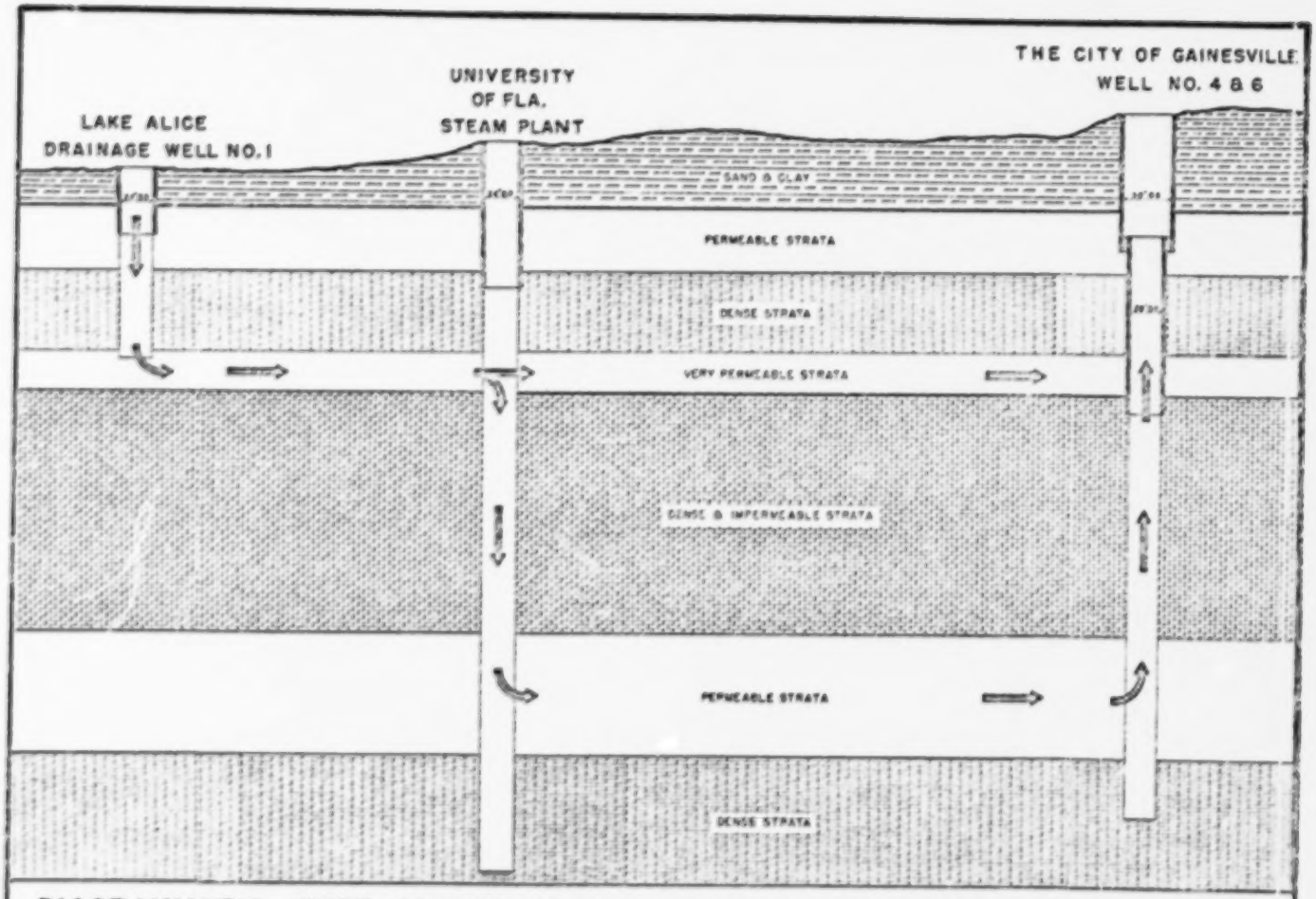


Fig. 15- DIAGRAMMATIC WEST TO EAST CROSS-SECTION INDICATING POSSIBLE PATH OF POLLUTION

comparing the effectiveness of chlorine and iodine as disinfectants in a distribution system. Virology studies would be the next step in this comparison. Data obtained during a period of chlorination are presented in Table 6 .

Sections of pipe removed from both the old and new parts of the distribution system have been used in the laboratory to determine (a) the persistence of HIO and NH_2Cl with time and (b) the buildup of IO_3^-. The data would be expected to reflect the effect, if any, of the various types of pipe coating, scale, tuberculation and organic matter on each of these vectors.

Table 6

Coliform and Standard Plate Count in the Distribution System During a Period of Chlorination

Sample Points*	Nov 8 1966	Nov 15 1966	Nov 29 1966	Dec 13 1966	Dec 20 1966	Dec 28 1966	Jan 10 1967
No. 3 - SPC	4	2	2	3	2	3	3
Coliform	<1	<1	<1	<1	<1	<1	<1
No. 5 - SPC	5	4	2	4	1	8	3
Coliform	<1	<1	<1	<1	<1	<1	<1
No. 8 - SPC	1	4	3	3	1	160	4
Coliform	<1	<1	<1	<1	<1	<1	<1
No. 11- SPC	3	3	1	2	4	>1000	6
Coliform	<1	<1	<1	<1	<1	<1	<1

*No. 3 - County Jail, 6th Street at 10th Avenue, S.E.
No. 5 - Holiday Inn, 13th Street at 18th Place, S.E.
No. 8 - Littlewood School, 34th Street at 8th Avenue, N.W.
No. 11 - Pepsi Cola Bottling Co., 1950 NE 27th Avenue.

Figures 16 and 17 show the persistence of HIO and chloramines with time in pipes from the old and new parts of the distribution system. Since the distribution system consists of a combination of old and new pipe the residual at any given time would be expected to be somewhere between the values found in each of the different pipes. These data suggest that chloramines can be used to maintain a low HIO residual in the distribution system by reoxidation of the iodide ion. It further suggests that at least 1 ppm of iodine as iodide will be required to maintain an HIO residual to the end of the distribution system since there is at least a 0.7 ppm HIO demand within the first 24 hours. These findings were later substantiated in the distribution system.

Both taste and odor slowly developed in each pipe; however, 24 to 48 hours were required for the taste and odor to become objectionable. Taste and odor developed more rapidly in the newer pipe with each pipe producing a different characteristic taste.

The formation of iodates at high pH proved to be of minor concern with less than 0.15 ppm present after 10 days at pH 8.5 to 9.0.

System Studies - Addition of Iodine to the Gainesville System

The detention time of water in the distribution system was determined by increasing the noncarbonate hardness of the finished water and determining the time necessary for the harder water to reach preselected points in the distribution system. These data, which are plotted in Figure 18 show that the detention time in most of the distribution system is less than 24 hours and that a detention time of 48 hours is exceeded in only a few dead end areas.

Since the detention time in most of the distribution system was determined to be less than 48 hours, and since pipe studies showed that taste and odor were no problem within that period of time, 1.0 ppm of iodine as the iodide ion was added to the chloramine residual leaving the water treatment plant for a brief trial run. The test was begun at 8:00 AM on Thursday, February 23, the objective of the trial run being to determine (a) if an HIO residual could be maintained to the ends of the distribution system, (b) if there is a buildup of taste and odor, and (c) if buildup of iodate is appreciable.

Iodination of the supply was terminated after 12 hours due to the presence of an objectionable taste and odor over a wide area of the city, which had not been predicted by any of the laboratory work.

Experiments using pipe from the old and new part of the distribution system were repeated to confirm earlier results regarding taste and odor. The results show that a slight taste is detected in the water prior to 12 hours and that more than 48 hours are required for odor and taste to become pronounced. Comparison of results obtained using pipe and those using glass containers show that taste and odor are enhanced in the pipe. Further studies will center around elucidating the agent responsible for the observed taste and odor.

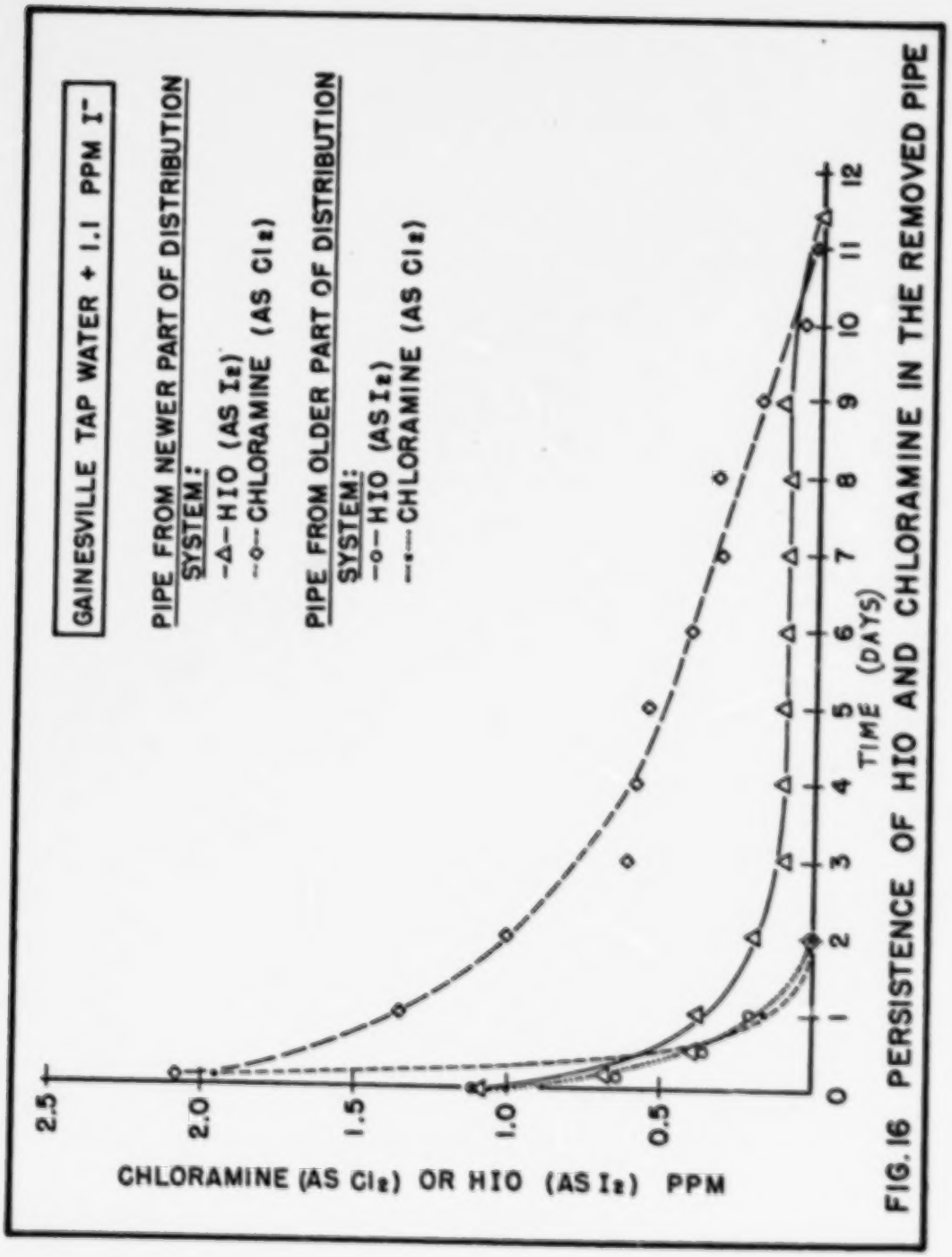


FIG. 16 PERSISTENCE OF HIO AND CHLORAMINE IN THE REMOVED PIPE

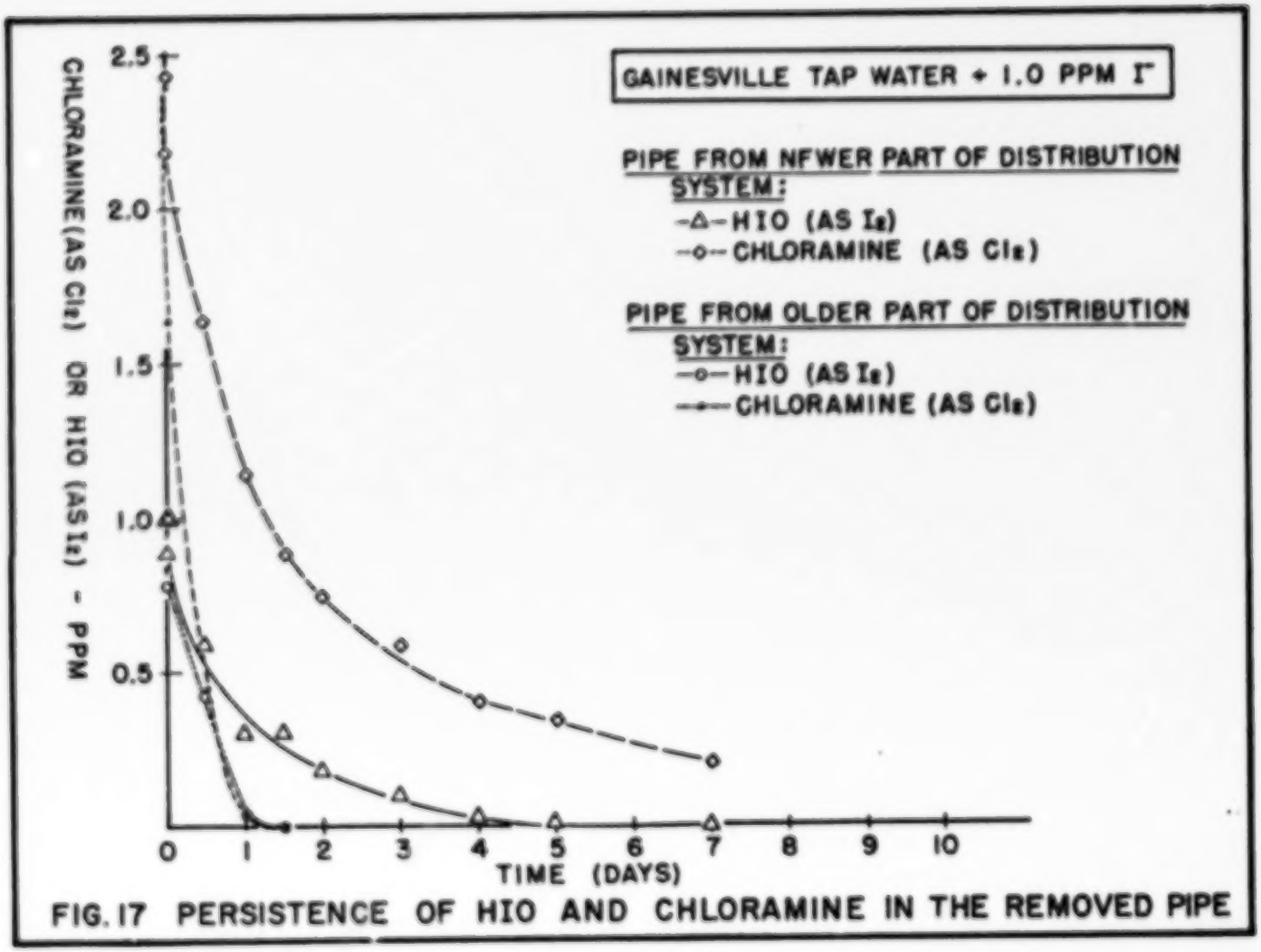


FIG. 17 PERSISTENCE OF HIO AND CHLORAMINE IN THE REMOVED PIPE

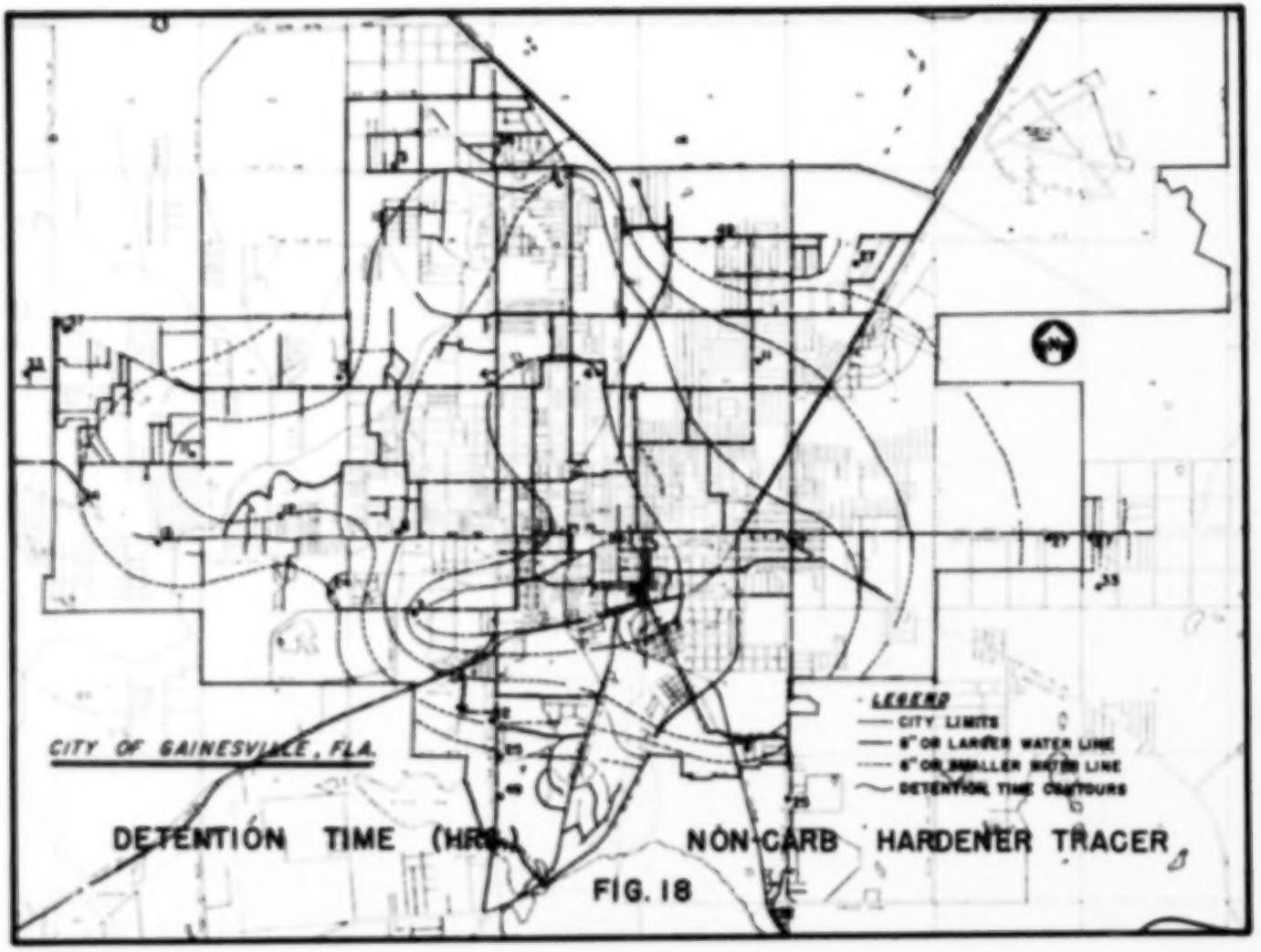
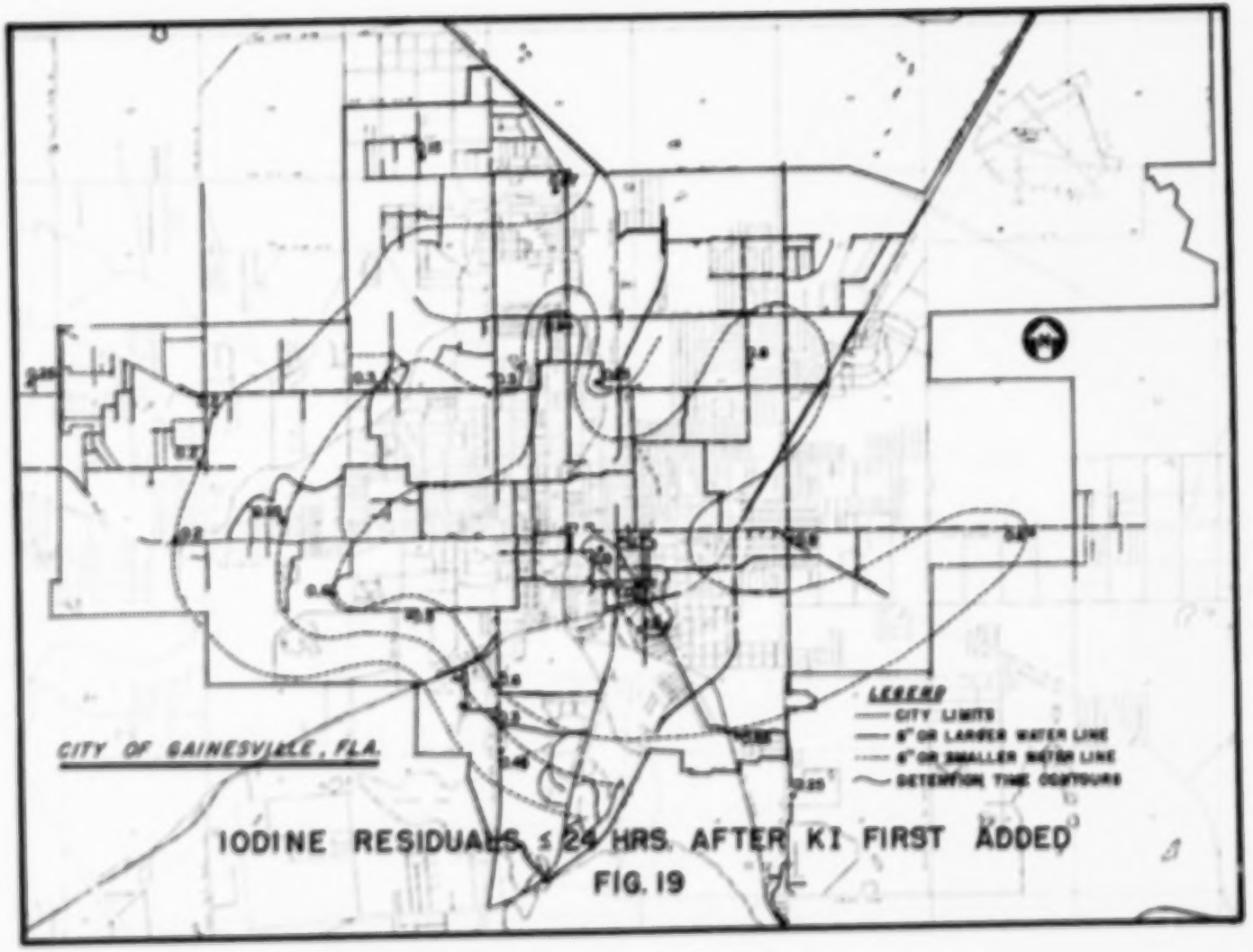

LEGEND
CITY LIMITS
6" OR LARGER WATER LINE
4" OR SMALLER WATER LINE
DETENTION TIME CONTOURS
CITY OF GAINESVILLE, FLA.
DETENTION TIME (HRS.) NON-CARB HARDENER TRACER

FIG. 18

HIO residuals in the distribution system were determined for 24 hours after iodination was begun. These data, which are plotted in Figure 19, show that an HIO residual was maintained to the ends of the distribution system by reoxidation of the iodide ion. Data on residuals over a longer period of time could not be obtained, since all mains were flushed in an effort to eliminate taste and odor in the water.

Iodate determinations made on 17 samples taken from the distribution system while the water was iodinated showed a maximum value of 0.18 ppm with 11 of the values less than 0.1 ppm and a mean value of 0.08 ppm for all determinations. Due to the method used for the analysis these values are believed to be high. Another method of analysis will be used for confirmation of these values.



IODINE RESIDUALS ≤ 24 HRS. AFTER KI FIRST ADDED

FIG. 19

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C. Swimming Pool Studies

1. Selection of pools studied

Five public pools in Gainesville, Florida, were studied during the summer of 1966. The purpose of this study was to compare chemical costs, effectiveness of disinfection, pH and halogen residual stability and organic buildup in actual pool operation. A physical description of the pools studied is given in Table 7.

Table 7

Basic Data on Five Pools Studied

Pool	Size	Capacity Gallons	Type of Filters	Type of Chlorine	Turnovers per day
University	60' x 150'	500,000	Diatomite	Gas	3
Lincoln	42' x 75'	148,000	Diatomite	Gas	4
Faculty Club	35' x 70'	98,600	Diatomite	Gas	3
Ramada Inn	25' x 50'	52,500	Diatomite	HTH	4
Northwood	L-shaped	228,000	Diatomite	Gas	3

2. Bacteriology

The effectiveness of disinfection was followed by sampling three "test" pools twice daily and the control pools once weekly for coliforms, enterococci, and staphylococci. Also, 48-hour plate counts were run and the percentage of coagulase positive staphylococci determined, giving some indication of the number of potentially pathogenic staphylococci present. The results for each pool are summarized in Tables 8-10. Numbers for coliform, enterococci, and plate counts represent an average of six samples, while the staphylococci data are the average of two samples.

3. Costs

Chemical costs for each pool were computed by dividing the total cost for a given disinfectant period by the number of days operation, giving an average cost per day. This was done to compensate for abnormally high chlorine demands, because of the instability of chlorine, during the

Table 8

Summary of Bacteriology - Free Chlorine

Pool		Organisms				No. of Samples	Ave. Daily Load	% Positive Confirm Coli	% Positive Confirm Strep	% Positive Confirm Staph	Ave. Residual ppm
		Coliform	Strep	Staph no./100ml	Plate Count						
University	Ave.	0.82	0.48	51.7	7.8	179					
	Range	<2.2→23.0	<2.2→23.0	0→410.	0←3200	31 Staph	153	5.6	6.1	14.4	0.5
Lincoln	Ave.	0.87	0.88	32.2	22	158					
	Range	<2.2→23.0	<2.2→23.0	0←119	0←420	34 Staph	130	9.5	12.6	24.5	0.5
Faculty Club	Ave.	0	0.08	-	5.4	24					
	Range	<2.2	0→2.2	-	1←41	-	175	0	4.1	-	0.6
Ramada Inn	Ave.	0	0	-	97.4	12					
	Range	<2.2	<2.2	-	0←500	-	19	0	0	-	0.6
Northwood	Ave.	0	0.25	-	181.4	39					
	Range	<2.2	0→5.1	-	1←4000	-	80	0	5.1	-	0.6

Table 9

Summary of Bacteriology - Iodine

Pool		Organisms				No. of Samples	Ave. Daily Load	% Positive Confirm Coli.	% Positive Confirm Strep	% Positive Confirm Staph	Ave. Residual ppm
		Coliform	Strep	Staph no./100ml	Plate Count						
Faculty Club	Ave.	0.09	0.18	18.4	610	30	119	4.2	8.4	17.4	0.5
	Range	0 ← 22	0 → 2.2	5 ← 39	2 ← 2200	10 Staph					
Ramada Inn	Ave.	0	0.43	-	104	12	25	0	8.4	-	0.6
	Range	<2.2	0 ← 5.1	-	0 ← 200	-					
Northwood	Ave.	0	0.25	-	181	39	80	0	5.1	-	0.6
	Range	<2.2	0 ← 5.1	-	1 ← 1400	-					

Table 10

Summary of Bacteriology - Chloramine

Pool		Organisms				No. of Samples	Ave. Daily Load	% Positive Confirm Coli.	% Positive Confirm Strep	% Positive Confirm Staph	Ave. Residual ppm
		Coliform	Strep	Staph no./100ml	Plate Count						
Lincoln	Ave.	4.2	3.7	53.5	72.7	33	63	36.3	33.3	28.0	1.3
	Range	<2.2 ← 23.0	<2.2 ← 23.0	10 ← 209	1 ← 380	10 Staph					

months of long hot days and higher bather loads. A summary of the chemical costs for the entire test period is given in Table 11.

Table 11

Average Chemical Costs per Day

Pool	Chlorine			Iodine		Chloramine
	June	July	August	July	August	August
University	$4.16	$5.65	$6.16	*Please see below		--
Lincoln	4.24	4.70	4.60	--	--	$0.70#
Faculty Club	2.77	2.34	1.79	$0.75	--	--
Ramada Inn	1.23	1.23	1.26	0.45	--	--
Northwood	3.47	4.74	--	1.55	$1.20	--

*This pool has been disinfected with iodine most of the time during the past two years. Complete cost data are kept and indicate an average daily cost of $2.18, which includes not only the cost of the KI and the Cl_2 required to release the I_2, but an additional 150 lb. cylinder of Cl_2 for algae burnout each month.

#Nine-day period only.

4. Conclusions and recommendations

(a) Both "free" chlorine and iodine are excellent swimming pool disinfectants. Combined chlorine (chloramine) is not suitable for swimming pool disinfection.

(b) The cost of disinfection using iodine is about one-third to one-half that of chlorine. The factors responsible for this lower cost are: (a) no soda ash is required for pH adjustments, and (b) the iodide ion can be reoxidized to iodine several times. Chloramines are significantly cheaper to use than free chlorine, but they are not bacteriologically effective.

(c) Chlorine residuals are extremely unstable and fluctuate considerably with both bather load and sunlight. Iodine residuals, on the other hand, are very stable and are easy to maintain at any desired level.

(d) Ammonium compounds build up steadily in iodinated pools and in pools on chloramine, but no significant increase is noted in pools on free chlorine.

(e) Filter head losses build up more readily in iodinated pools than in chlorinated pools, resulting in an increase in the number of filter backwashes required.

(f) Algae are more readily controlled in pools using free chlorine than in pools using either iodine or chloramine. Even under normal weather conditions and with no excessive algae blooms, it is necessary to superchlorinate an iodinated pool at three- to four-week intervals, depending on pool load and water circulation in the pool.

(g) Total plate counts will tend to gradually increase with time in an iodinated pool. This behavior may well be related to the steady buildup of head loss in the filters. Both may be controlled, as has been shown, by superchlorination as required.

(h) Little or no pH control is required in iodinated pools. This is also true of combined chlorine residuals, which persist over long periods of time. The pH of chlorinated pools tends to be erratic and requires frequent and relatively expensive adjustment. This is important since low pH values increase eyeburn whereas high values substantially lower the disinfecting power of a given residual.

(i) The orthotolidene method for the determination of free chlorine residuals, which must be carried out on samples chilled to 1°C or 34°F, is neither simple nor accurate. A new rapid, accurate colorimetric method for the determination of free chlorine residuals in the presence of combined chlorine and at warm pool water temperatures has been developed at the University of Florida. We have also developed a rapid, accurate colorimetric method for the determination of iodine residuals. Test kits employing both methods are presently available from at least two manufacturers and will shortly be offered by several others.

(j) The use of either lithium iodide or sodium iodide in place of potassium iodide may materially decrease the rate of development of algae, and both are presently being used in a new series of studies.

(k) In summary, we have found that (a) from the standpoints of bactericidal effectiveness, uniformity and stability of both halogen residuals and pool pH, ease of operation, total cost and bather acceptance, iodine is the preferred disinfectant for swimming pool water. Its widespread use for that purpose awaits only the development of an effective and compatible algaecide; and (b) all regulatory agencies, in order to insure equally effective results with chlorine, should require, as does the APHA, suggested ordinance that "when chlorine is used, a free chlorine residual of at least 0.4 ppm shall be maintained throughout the pool whenever it is open or in use."

5. New Methods for the Determination of Iodine and Free Chlorine Residuals

The widespread use of iodine for water disinfection would obviously require the development, if possible, of a simple, rapid, accurate colorimetric test for the determination of iodine and iodide residuals. Also, it is becoming more and more recognized that the orthotolidine test for determining chlorine residuals, as usually performed, yields results that are misleading in terms of the forms in which the chlorine is actually present.

Accordingly, study was directed to both of these problems and new methods were developed for the determination of both halogens. Papers presenting complete information with respect to the development and use of each method have been submitted for publication in the Journal of the American Water Works Association and should appear shortly. The editor of "Standard Methods for the Examination of Water and Waste Water," Michael Taras, has requested that both be prepared and submitted in the format employed by that standard reference source, and that is presently being done.

Complete information concerning each test has been supplied to every known manufacturer of test kits and most, if not all of them, will have test kits available during 1967.

6. Special Studies

(a) Lithium iodide and sodium iodide. The problem of algae control was of some concern during the latter part of the bathing season. Potassium iodide was used as a source of iodine and the fact that potassium is one of the essential nutrients, is of potential significance. Accordingly, other sources of iodide were tried in order to lessen the possible food source for algal growth. Both lithium and sodium iodide have been used, but algae blooms still occur within a week to ten days.

(b) Ozone. In still another attempt to control algae and at the same time to release iodine from iodide, ozone was used. A rapid buildup of iodate was found, thereby eliminating ozone from further study.

(c) Reducing agents for IO_3^-. The problem of iodate buildup is of some importance, due to the fact that the PHS provisional approval of iodine for pool disinfection limits the total concentration of the three forms of iodine, namely, iodine, iodide and iodate, to 5 ppm. Accordingly, work has been begun on a search for a suitable reducing agent. Chemicals such as sodium metabisulfite, hydroxylamine hydrochloride, and hydrazine have been tested in the laboratory. Reduction is readily accomplished at low pH, but the problem of reducing iodate to iodide at pH levels above 4.0, even with excess iodide ion, has not as yet been solved. These studies will be continued.

(d) New oxidizing agents for I^-. We are presently studying oxidizing agents that oxidize iodide to hypoiodous acid but not to iodate. We have shown that chemicals such as potassium persulfate and hydrogen peroxide do this in laboratory studies at pool pH and pool studies are planned. A number of other potential oxidizing agents will be screened.

(e) Algaecides.

1. Hyamine 3500. Hyamine 3500 is a blend of three quaternary ammonium compounds and has been reported to be an effective algaecide in swimming pools. It has been used in the recommended initial dosage of 2 ppm, maintaining a residual of 1-1.5 ppm, for a period of two weeks. These first tests indicate it to be an effective algaecide, but pseudomonas buildup is greatly accelerated. Studies are now in progress to determine the species of pseudomonas that develop, since Pseudomonas aerugenosa is a potential pathogen causing ear and eye infections and has been found in swimming pools. Other reports indicate that certain quaternaries, while extremely effective at high dosages, act as nutrients for pseudomonas in low concentrations. Another possibility is that the Hyamine may kill off other organisms that may hold back the metabolism of pseudomonas and once these organisms are gone pseudomonas grows. These are all possibilities, and until further research is done, Hyamine 3500 is not recommended for algae control in swimming pools.

2. Algimycin. Algimycin is a mercury compound, reported to be nontoxic in concentrations used in swimming pools, and offered as an effective algaecide. The manufacturer of this material, Dr. Robert Stern, has offered to supply the material on a no-cost basis and to personally initiate the test, and it is being programmed for early spring.

(f) Comparison of the bacteriocidal effectiveness of chlorine and iodine in swimming pool disinfection.

The objective of the studies summarized below was to compare the effectiveness under routine pool operation of free residual chlorine, combined chlorine, and iodine as swimming pool disinfectants. Optimum halogen residuals and optimum pH's were defined as: free residual chlorine 0.4-0.6 mg/l at 7.4-7.6 pH, combined residual chlorine (assured by adding an excess of $(NH_4)_2SO_4$ to the soda ash feed) 0.4-0.6 mg/l at pH 7.4-7.6, and iodine at free residual of 0.7-1.0 and pH 7.6-7.8. Coliform mpn and fecal streptococci were studied as indicators of fecal contamination. The former is the traditional indicator of contamination of enteric origin while fecal streptococci have been found by some investigators to be more resistant to disinfection than coliforms. Staphylococci, potential pathogens, but members of the normal flora of human skin, nasal, and buccal cavities were studied as indicators of contamination of the water by organisms derived from nose, mouth and skin surfaces. A 48-hour plate count was also determined as a measure of the sterility of the waters. Laboratory studies are in progress to compare the resistance of cultured strains of Escherichia coli, Streptococcus Fecalis and two strains of Staphylococcus to the above disinfectants under controlled conditions of residual and pH.

Fecal streptococci - The tentative multiple tube technique employing sodium azide broth with confirmation on ethyl violet azide broth (EVA). Confirmation was recorded only when short chains of large, oval, gram positive cocc were found in gram strains of the EVA tubes.

Staphylococci - Millipore filtration of 100 to 500 ml of pool water followed by incubation for 48 hours on M-Staphylococcus broth (Difco). When possible coagulese activity and possible pathogenicity were tested by replica plating from the filter onto coagulese agar, mannitol salt agar and tellurite glycine agar.

Plate count - 48-hour counts were recorded on tryptone glucose yeast extract agar.

Coliforms - The multiple tube technique using lactose fermentation tubes with confirmation on brilliant green bile.

Laboratory study - The conditions of Ortenzio and Stuart, (L. F. Ortenzio and L. E. Stuart; J. Assoc. of Official Agric.

Chemists; Vol. 47; June 1964) have been employed. The test organisms are: Escherichia coli ATCC 11229, Streptococcus fecalis LHB 2 (R. A. Taft Center), Staphylococcus aureus ATCC 12600, Staphylococcus Epidermitis ATCC 12228.

Two large outdoor pools were studied extensively through the summer and fall of 1966. These were the Gainesville Municipal pool and the University of Florida swimming pool. Owing to algae problems during the summer, iodine disinfection was employed only at the University pool for an extended time period. Data on free residual chlorine was obtained from both pools and data on combined residual chlorine was obtained from the Gainesville Municipal pool only.

Results and observations - The data collected on free residual chlorine is condensed in Tables 12 and 13. It was found that the waters met USPHS Drinking Water Standards with respect to the percentage occurrance of coliforms; however, the allowable percentage occurrance of three positive tubes per sample was slightly exceeded. Fecal streptococci appeared to be slightly more resistant than coliforms to this type of disinfection. Six of seven pools sampled at least once weekly during this study showed a higher incidence of positive fecal streptococci. This is in accord with results obtained by Mallman. Staphylococci counts were in the same range reported by Favero for chlorinated pools. The counts were variable but did not tend to correlate with plate count. A small but significant number of coagulase positive staphylococci appeared to be present at all times. This study indicated that staphylococci were somewhat more resistant to free residual chlorine than the other organisms studied.

Table 12

University of Florida Pool on Free Residual Chlorine*

Dates of sampling May 31 - August 15, 1966

Organism	Average	Range
Coliform (MPN)	5.6%**	-
Fecal Streptococci (MPN)	6.1%**	-
Staphylococci		
Total	51.7 organisms/100 ml	0-410 organisms/100 ml
% coag. positive		
Plate counts	7.8 organisms/ml	0-3200 organisms/ml

*Number of samples - 179 coliform, plate count and fecal strep.; 31 staphylococci.

**Figure represents the overall percentage of positive confirmed samples.

Table 13

Gainesville Municipal Pool on Free Residual Chlorine*

Dates of sampling June 8 - August 15, 1966

Organism	Average	Range
Coliform (MPN)	9.5%**	--
Fecal Streptococci (MPN)	12.5%**	--
Staphylococci		
Total	32.2 organisms/100 ml	0-119 organisms/100 ml
% coag. positive	24.5%	0-83%
Plate Count	22 organisms/ml	0-420 organisms/ml

*Number of samples - 158 coliform, plate count and fecal strep.; 34 staphylococci.

**Figure represents the overall percentage of positive confirmed samples.

Table14 summarizes the results of disinfection with combined chlorine. During the ten-day period studied bacteriology was generally unsatisfactory with respect to coliform counts. A high incidence of fecal streptococci and a higher average staphylococci count were found. Plate count also increased markedly.

Table15 summarizes the results obtained on free iodine released from KI or NaI by gaseous chlorine. Results indicate that iodine may be somewhat superior to chlorine in its ability to control coliform bacteria and fecal streptococci and that it appears to be much more effective than chlorine in reducing the number of staphylococci in swimming pool water. Plate counts ranged much higher when iodine was used than chlorine. Gram stains of colonies picked from plates showed a predominance of a gran negative rod. No attempt has yet been made in this investigation to isolate and identify this organism. There is a possibility that this organism reproduces in the filter as was suggested by Favero. High plate counts were often obtained after backwashing in the absence of positive coliforms, fecal streptococci and along with low staphylococci counts.

Table 14

Gainesville Municipal Pool on Combined Residual Chlorine*

Dates of sampling June 8 - August 15, 1966

Organism	Average	Range
Coliform (MPN)	36.3%**9	--
Fecal Streptococci (MPN)	33.3%**	--
Staphylococci		
Total	53.5 organisms/100 ml	10-209 organisms/100 ml
% coag. positive	28%	18-37%
Plate Count	72.7 organisms/ml	1-380 organisms/ml

*Number of samples - 33 coliform, plate count and fecal strep.; 10 staphylococci.

**Figures represent the overall percentage of positive confirmed samples.

Table 15

University of Florida Pool on Free Iodine*

Dates of sampling Sept. 21 - Oct. 18 and Nov. 14 - Dec. 8, 1966

Organism	Average	Range
Coliform (MPN)	2.38%**	--
Fecal Streptococci (MPN)	3.56%**	--
Staphylococci	3.5 organisms/100 ml	0.2 - 25.0 organisms per 100 ml
Plate Count	2290# organisms/ml	38 - 26,000 organisms per ml

*Number of samples - 84.

**Figures represent the overall percentage of positive confirmed samples.

#Does not include two samples taken immediately after filter backwash.

The laboratory studies have indicated that 0.4 mg/l free chlorine reduced the E. coli concentration to 0 within two minutes and that I_2 would do the same at 1.40 mg/l concentration. Combined chlorine had little effect on E. coli. The disinfecting power of chlorine and iodine decreased with increasing pH. The kill rate seemed to be more rapid at higher temperatures. Streptococcus fecalis reacted the same way as E. coli except it appeared to be more resistant to both disinfectants and its resistance less influenced by pH. On the basis of very limited results the coagulase positive staphylococci seemed to be less resistant than the streptococcus but more than the E. coli. Further studies are being done at this time using both Staphylococcus aureus and Staphylococcus Epidermitis at various combinations of pH and halogen residual to attempt to determine if the earlier results are correct for the coagulase and staph, if so why does this organism appear to behave differently (i.e. be very resistant) in swimming pool situations.

3 (b). Probable New Extensions of Activity

A. Marietta, Ohio.

A request was received from officials of a major industrial plant in the state of Ohio that that part of the water used as a public water supply be iodinated. The plant in question is the Mine and Metals Division of the Union Carbide Corporation at Marietta, Ohio, employing about 2000 people. The water was believed to contain phenols since chlorination was producing highly objectionable tastes and odors. The request was approved by the Ohio Department of Health. While phenols were reported to be causing the taste and odor problem, a visit to the plant revealed that other agents were responsible. Laboratory analysis of the raw water revealed the presence of ammonia in excess of 100 ppm and the characteristic odor of chlorbenzene. Company officials were advised that a new source of water should be obtained prior to iodinating the supply.

B. Champaign-Urbana, Illinois.

The water system of the cities of Champaign-Urbana, Illinois, is owned and operated by the Northern Illinois Water Corporation. The attached letter from Mr. Charles H. Smith outlines an unusual problem which has long plagued the system, and which they feel might be solved wholly or in part by intermittent feed of iodine. Professor John H. Austin of the Department of Civil Engineering of the University of Illinois has expressed interest in the problem and has stated that it may be possible to assign a graduate student to make preliminary studies in a pilot plant and later, in the system itself, if such a trial should be decided upon. Correspondence now in progress may result in the addition of the study area to those now in progress.

C. Cooperative Swimming Pool Study in DeKalb County, Georgia.

Recently the project was visited by Mr. Fred E. Johnston, Senior Engineer of the Georgia Department of Public Health. That department is preparing to cooperate with the DeKalb County Recreation Department during the summer of 1967 in a comparison of chlorine, bromine and iodine as disinfectants for swimming pool water. Since such a comparison, under carefully supervised conditions, has never been made, to our knowledge, this study should provide valuable data, and we have, therefore, offered our assistance by placing the pool to be iodinated into operation and instructing the personnel of the project in the details of its proper operation. Copy of a letter just received from Mr. Johnston will supply further information.

D. Cooperative Study of the Disinfection of Vegetables with Iodine in Caracas, Venezuela.

Recently, the project was visited by Dr. J. R. Hurtado, consulting engineer and water chemist of Caracas, Venezuela, for advice on a method for using iodine for the disinfection of truckload and carload lots of fresh vegetables to be sold in government owned supermarkets in Caracas.

The effectiveness of iodine for this purpose has long been known but the reoxidation and reuse of the iodide ion on the scale contemplated by this study needs further investigation. A letter from Senor Antonio M. Calcaño H., President, MERCADOS, SILOS Y FRIGORIFICOS DEL DISTRITO FEDERAL, C.A., is part of this report. My firm has been retained by the Government of Venezuela to work with Dr. Hurtado on a water problem in that country, and this fortunate circumstance provided an opportunity to visit with Senor Calcaño in Caracas on February 28. It develops that this organization is a very large operation supported by the government but operated as a private company whose objective is to lower the cost of living for the workers of the country by providing fresh farm products directly from the producer to the consumer through 17 supermarkets without profit by this company. This, therefore, becomes a major project since iodine has been selected as the element to be used for disinfection. A two-hour discussion with Senor Calcaño and members of his staff convinced me that this project should be recommended to the World Health Organization with a request for their cooperation, and this will be done. We have received a request from WHO (as noted below) for specific suggestions as to areas in which they might work, and this appears to be an ideal one.

E. World Health Organization

We have been requested by Mr. W. E. Wood of the Division of Environmental Health, Community Water Supply, to make suggestions concerning possible studies on the use of iodine which might be carried out in various parts of the world. Correspondence is in progress and our assistance will be tendered when and if requested.

3 (c) Project Staff, July 1, 1966 - February 28, 1967

Professional	Period of Service	Time Basis
A. P. Black	July 1, 1966 - Feb. 28, 1967	50%
W. C. Thomas,Jr.	July 1, 1966 - Feb. 28, 1967	7.5%
R. P. Vogh	July 1, 1966 - Feb. 28, 1967	5%
Annie L. Smith	July 1, 1966 - Feb. 28, 1967 (Leave of absence Dec. 1-18, 1966)	100%
W. E. Harlan	May 1, 1966 - Aug. 30, 1966 Sept. 1, 1966 - Feb. 28, 1967	100% 5%
W. P. Bonner	July 1, 1966 - Feb. 28, 1967	100%
M. A. Keirn	July 1, 1966 - Feb. 28, 1967	100%
A. A. Jabero	May 11, 1966 - Feb. 28, 1967	100%
J. J. Smith,Jr.	July 1, 1966 - Feb. 28, 1967	100%
G. P. Whittle	Aug. 16, 1966 - Jan. 31, 1967	100%
H. Asano	Sept. 1, 1966 - Feb. 28, 1967	100%
M. C. Jayaswal	Nov. 1, 1966 - Feb. 28, 1967	5%
Ching-lin Chen	July 1966 only	100%
Technical - Nonprofessional		
M. R. Whittle	July 1, 1966 - Jan. 31, 1967	100%
Pauline Gubbins	July 1, 1966 - Feb. 28, 1967	100%
Virginia Morgan	July 1, 1966 - Feb. 28, 1967	50%
Secretarial		
Janice G. Larson	July 1, 1966 - Feb. 28, 1967	100%
Laboratory Assistants		
Albertha Pringley	July 1, 1966 - Feb. 28, 1967	50%
Ben Bozman		Hourly
Dan White		Hourly

D. Presentation of Papers, Publications and Degrees Awarded

Papers presented:

1. "The Chemistry, Technology and Physiology of Iodine in Water Disinfection." 29th Annual Educational Conference, National Association of Sanitarians, Miami Beach, Florida, June 1965, A. P. Black, R. N. Kinman, W. C. Thomas, Jr., Gerhard Freund, and E. D. Bird.

2. "Iodine for Water Disinfection." Annual Conference Southeastern Region, National Association of Soft Water Service Operators, Gainesville, Florida, October 1965. A. P. Black and R. N. Kinman.

3. "Iodine for Water Disinfection." Joint annual meeting, Florida Section AWWA and Florida Section, Water Pollution Control Federation, Jacksonville, Florida, November 1965. A. P. Black and R. N. Kinman.

4. "Iodine for the Disinfection of Swimming Pool Water." Annual Meeting, National Swimming Pool Institute, Houston, Texas, January 1966. A. P. Black and R. N. Kinman. Formal paper and panel discussion.

5. "Effectiveness of Iodine for the Disinfection of Swimming Pool Water." Presented by invitation to the British Association of Baths Management at the annual conference held in London on October 6, 1966. Paper and slides prepared by project staff and presented by Mr. R. W. King, Consulting Chemical Engineer, 19 Grosvenor Place, London, S. W. 1, England.

6. Seminar presented by invitation to Radioactive Waste Disposal Research Section, Health-Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn. in February 1967 by W. Paul Bonner, titled "Factors Involved in the Iodination of Public Water Supplies."

7. National Swimming Pool Institute, Las Vegas, Nevada, Jan. 26-29, 1967; Executive Seminar on Water Chemistry and Dr. A. P. Black presided as Work-Shop Chairman on "Disinfection of Swimming Pool Water with Iodine" for two hours.

Papers published:

1. "The Use of Iodine for Water Disinfection." A. P. Black, R. N. Kinman, W. C. Thomas, Jr., Gerhard Freund, and E. D. Bird. Jour. AWWA, 57, 1401 (1965).

2. "Effect of Iodinated Water on Thyroid Function." G. Freund, E. D. Bird, W. C. Thomas, Jr., R. N. Kinman, and A. P. Black. Jour. Clin. Endocrinology and Thyroid Metabolism, 26, 619-624 (June 1966).

3. "The Disinfection of Swimming Pool Water with Iodine." A. P. Black, R. N. Kinman, and G. P. Whittle. Swimming Pool Age, 40, 74 (Jan. 1966).

4. "Swimming Pool Disinfection with Chlorine, Chloramine and Iodine." A. P. Black, W. E. Harlan, J. J. Smith, Jr., M. A. Keirn and A. A. Jabero. Swimming Pool Age, 41, 37 (Jan. 1967).

5. "How to Use Iodine As a Sanitizer." A. P. Black, J. J. Smith, Jr., and W. E. Harlan. Swimming Pool Age, 41, 50 (Jan. 1967).

6. "Iodine for the Disinfection of Swimming Pool Water." The Institute of Baths Management, Inc. 36th Annual Conference, 1966. A. P. Black and R. N. Kinman. Pp. 110-116.

In press:

1. "New Methods for Determining Iodine and Free Chlorine Residuals in Swimming Pool Water." Submitted for publication in Swimming Pool Age. A. P. Black, and G. P. Whittle.

2. "New Methods for the Colorimetric Determination of Halogen Residuals. Part I. Iodine, Iodide and Iodate. Submitted for publication in Jour. AWWA. A. P. Black and G. P. Whittle.

3. "New Methods for the Colorimetric Determination of Halogen Residuals." Part II. Free and Total Chlorine. Submitted for publication in Jour. AWWA, A. P. Black and G. P. Whittle.

Papers scheduled:

1. "New Method for the Colorimetric Determination of Iodine and Free Chlorine Residuals in Water." To be presented to Water, Air and Waste Chemistry Division, ACS, April, 1967 by A. P. Black and G. P. Whittle in Miami, Florida.

2. "Iodine for the Disinfection of Water." To be presented to the annual meeting of AWWA in June, 1967 in Atlantic City, N. J. by A. P. Black, W. C. Thomas, Jr., and W. P. Bonner.

3. "Resistance of Staphylococci to Halogenated Compounds as Related to Swimming Pool Disinfection." To be presented to American Public Health Assoc. Annual Meeting, Miami Beach, October 1967, by Hugh Putnam and M. A. Keirn.

4. "Iodination of Public Water Supplies." To be presented to the American Public Health Assoc. Annual Meeting, Miami Beach, October 1967 by A. P. Black, W. P. Bonner and J. J. Smith, Jr.

Graduate degrees awarded:

1. G. P. Whittle, M.S., August 1964. Title of thesis: " A New Colorimetric Method for Determining Iodine Residuals in Water."

2. R. N. Kinman, Ph.D. December 1965. Title of dissertation: "The Disinfection of Public Water Supplies with Elemental Iodine."

3. G. P. Whittle, Ph.D. August 1966. Title of dissertation: "New Methods for Colorimetric Determination of Halogen Residuals."

Degrees to be awarded:

1. J. J. Smith, Jr., B. Sc., April 1967.

2. A. A. Jabero, M.S., April 1967. Title of thesis: "Effect of Water pH on Use of Iodine for Disinfection."

3. M. A. Keirn, M.S., April 1967. Title of thesis: "Resistance of Staphylococci to Halogenated Compounds as Related to Swimming Pool Disinfection."

4. W. P. Bonner, Ph.D., August 1967. Title of dissertation: "Iodination of Public Water Supplies."

State of Georgia
Department of Public Health
JOHN H. VENABLE, M. D., DIRECTOR 47 TRINITY AVE. ATLANTA, GEORGIA 30334

February 20, 1967

Dr. A. P. Black
P. O. Box 1329
Gainesville, Florida 32601

Dear Dr. Black:

Please accept my sincerest appreciation for the time, information and courtesy received from you, Dr. Paul Bonner, and Mr. Jack Smith during my visit to your office on February 9 and 10. It had never been my good fortune to find such explicit and authoritative information made so readily available.

The depth of your work on bactericidal uses of iodine becomes increasingly impressive as I become more involved in study of the material brought back. So far I have been unable to even approximate this range of data with reference to bromine.

During the week of February 27 we plan to meet with officials of the DeKalb County Recreation Department for further planning of our proposed swimming pool study (comparing chlorine, iodine and bromine as bactericides) during the summer of 1967. The possible availability through your office of iodine, as well as technical assistance from Mr. Jack Smith, are both most welcome and will aid immeasurably in arranging for this study. As soon as the program plans become more definite as to location, personnel and operations we will be in touch with you again.

Permit me again to thank you and your staff for your many favors and hospitality during my visit as well as for your interest and active assistance with our proposed study.

Sincerely,

Fred E. Johnston,
Senior Engineer

FEJ:sc

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February 15th, 1967

PS-84

Dr. A.P. Black,
Office of Project Director
Iodine Demostration Project Grant,
Federal Water Pollution Control Administration
P.O. Box 1329,
Gainesville, Florida - 32601

Dear Dr. Black:

Through our mutual friend and Consultant for this Government Institution, Dr. J.R. Hurtado, we have had the opportunity of knowing your comments on the possibility of using iodine for vegetables desinfection.

Due to our tropical location, vegetables eaten in the raw form, are a public hazard on account of the contaminated water used for irrigation. As you know Endamaeba hystolica cysts are the most difficult patogenic organism to control due to their resistence to chlorine desinfection, so we have planned the application of iodine for such purpose.

It is a pleasure for us to send you a copy of the installation we are constructing now in one of our municipal super markets for the vegetable desinfection. Briefly it consists of an inmersion tank where the iodine will be kept in a concentration of 15 ppm, according to your recommendation to Dr. Hurtado. Air will be used for stirring; then the vegetables will go to another inmersion tank containing plain water to wash out the iodine solution. A final hand rinsing with spray will be given to secure complete removal of the iodine solution.

We are planning to continue a series of investigations once the Desinfection Station is in use to supply desinfected vegetables. These investigations will be carried on in accordance with our Board of Health to establish the effectivity of iodine ion as cysticide agent.

Dr. Black, we will highly appreciate your comments on our project and we will be delighted to keep you informed on the progress of our investigations.

Yours very truly,

Antonio M. Calcaño H.
President

56

cc: Dr. J.R. Hurtado
Oscar Baíz A.

OBA/im

WPD-19-04-66

January 26, 1967

Mr. Charles H. Smith
Production Manager
Northern Illinois Water Corporation
115 W. University Avenue
Champaign, Illinois 61820

Dear Mr. Smith:

As I told Dr. John Austin in a letter last week, we will be happy to cooperate in a study of the possible effectiveness of iodine for controlling growths in your distribution system if suitable arrangements can be made to do so. I have just returned from the annual conference of the National Swimming Pool Institute held at Las Vegas, Nevada, earlier this week, and while there I participated in a round table with Mr. William A. Honsof the Illinois State Department of Health. I mentioned your problem to him and we had time for a few moments' discussion but no more. I would suggest that you first secure the approval of your local health or administrative agencies or both as may be required, following which it should be cleared with the Illinois State Department of Health. If the necessary approvals are obtained we can then discuss specifics. I may say in that connection, that a similar request was made of us by a major industrial plant in the state of Ohio whose individual water supply is serving approximately 2000 employees in the plant. A request by that company for permission to feed iodine to their water supply, for a different reason, was approved by the Ohio State Department of Health as a research project.

I am familiar, in general, with your problem there since I believe it has been written up more than once in the Journal of the American Water Works Association. At any rate, it provides an excellent opportunity to test the effectiveness of iodine in a situation in which we have had no experience and, as I have said, we will be most happy to cooperate and to make available to you our four years experience in the use of this interesting and potentially very important element.

Very truly yours,

A. P. Black, Project Director

APB:jl

57

NORTHERN ILLINOIS WATER CORPORATION
"PLENTY OF QUALITY WATER MAKES THE DIFFERENCE"

January 20, 1967

Dr. A. P. Black
P. O. Box 1329
Gainesville, Florida 32601

Dear Dr. Black:

I have received the copy of the correspondence between yourself and Mr. Richard Pfieffer of the Chilean Iodine Eductional Bureau. Mr. Pfieffer also enclosed a number of article on iodine, compounds of iodine, and their effectiveness as a disinfectant in water supplies. After reviewing this information the idea of feeding iodine periodically to our water supply appears feasible.

Mr. Pfieffer felt you had done considerable research on the subject and were in a position to advise me. The problem we have is one caused by the amount of ammonia in the water. Wells are our source of water supply. The water has approximately 1.5 ppm of ammonia; the quantity varying according to our well combinations in use. The ammonia is apparently the food source for a filamentous heterogenequs growth. The growth is not a problem from a head loss viewpoint but rather poses a problem by completely depleting our chlorine residual in the extremities of the system. This we do not desire because of the potential hazzard which could result. Also, the growth imparts an odor to the water when the flow is not circulated rapidly enough. This results in complaints. Growth has also filled the bottom six inches of our storage facilities necessitating frequent cleaning.

The present solution is to break-point chlorinate fifteen days each spring and fall to destroy the growth. We then flush heavily to clean up the system. This procedure has also caused considerable problems.

The idea of intermittently feeding iodine appeals to me. I would hope we could maintain 1.0 ppm free iodine residual and obtain equal or better results than we do with 1.0 ppm free chlorine residual without the problems. We would only feed sufficient periods each year to destroy growth.

Yours thoughts on the subject would be appreciated. If there is some technical problem which I have overlooked please advise.

Yours very truly,

NORTHERN ILLINOIS WATER CORPORATION

Charles H. Smith,
Production Manager

58

CHS:mf
cc: Dr. John Austin

115 W. UNIVERSITY AVE., CHAMPAIGN, ILLINOIS 61820 ■ PHONE 217-356-2515